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A Great Shortage of Foundry Iron is Impending

In Meeting the Steel Works Needs, the Requirements of the Casting Manufacturers Have Not Been Considered and Immediate Relief is Necessary

AN ACUTE shortage of all grades of foundry pig iron is impending. Unless immediate steps are taken to relieve the situation, casting plants throughout the country will be without an adequate supply of melting stock. The difficulties now experienced in obtaining iron will be greatly increased after July when many blast furnaces now producing foundry metal will change to steelmaking grades. The situation is made more critical by the demands of steelmakers for an immediate diversion of the foundry product of some stacks to bessemer or basic. If their requests are granted, a further shrinkage in the foundry iron tonnage will result.

For nearly a year the distribution of the country's iron output has been inequitable. The needs of the foundrymen have been sacrificed for those of the steelmaker. In carrying out the war program the importance of steel has been exaggerated out of all proportion, particularly as compared with castings, and to the great detriment of the latter. The resounding cry has been for steel and the foundry product has been relegated to the background. But the time has arrived for giving more than passing consideration to the needs of the gray and malleable iron casting plants.

Without castings the battleships, destroyers, submarines, etc., would be without power plants and propellers. Without castings the tremendous shipbuilding program would be at a standstill. Without castings the ordnance department would be forced to a sudden halt. Without castings machine tools and equipment could not be built for fashioning the engines of war. And there are innumerable other needs for castings for government work, which evidently have been overlooked entirely in the anxiety of the authorities at Washington to keep the steelmakers supplied.

That practically 50 per cent of the foundries of the country are engaged on government work, either direct or indirect, is shown by the replies to a questionnaire sent out by the war service committee of the American Foundrymen's association, in making a survey of the foundry industry of the United States. A large merchant furnace interest recently sounded its customers to ascertain to what extent they are doing work for the government and considerably more than half listed castings that are needed in the prosecution of the war. Every day inroads are being made in the output of the casting plants to meet the pressing needs of the government. Recently, a contract was awarded for 500,000 trench mortar shells to be made of gray cast iron. Experiments now are being made in the manufacture of semisteel shells, which undoubtedly will result in the placing of initial orders for several hundred thousand and may ultimately be increased to millions. Deliveries are now being made by the foundries of millions of malleable cast iron rifle and hand grenades and the malleable shops recently have received contracts for several hundred thousand trench mortars.

Where is the pig iron coming from to make the castings for the freight cars that soon will be ordered? Although not definitely decided, it is certain that 100,000 cars are to be built and orders may be placed for 150,000. While the design of this new standard car reduces the number and weight of castings to the minimum, it is fair to assume that each car will have at least four tons. This provides for slightly more than 2½ tons for the cast iron wheels and less than 1½ tons for other castings. If 100,000 cars are purchased they will require 400,000 tons of castings, and if the program calls for 150,000 cars, 600,000 tons of castings will have to be provided. Nor have all of the castings been purchased for the thousands of motor trucks that will be used to maintain a stream of supplies for the army in France. It is reported that wheels for 25,000 motor trucks will be needed in the near future. Up to the present these wheels have been made of cast steel. However, the steel foundries are practically swamped with government work and the scarcity of low phosphorus iron has militated against capacity operations. Malleable iron foundries were requested to experiment in the manufacture of motor truck wheels and the tests proved so satisfactory that it has been decided to place at least a part of the order for 25,000 trucks, and probably all eventually, with malleable foundries. This order will involve about 12,500 tons of castings. And every day the casting needs of the government continue to increase. Crowding out nonessentials does not seem to provide the much needed slack to equalize foundry requirements to pig iron production at the present time.

Blast furnace capacity, during the last two years, has not kept pace with the tremendous increase in steel production. But proportionately, the growth of the foundry industry has been greater than that of the steel trade and the available tonnage of foundry iron has been declining. Blast furnaces that specialized on casting plant requirements have been purchased by steel plants and the output has been diverted to basic iron. Other steel plants operating their own stacks and which frequently had a surplus tonnage for the foundries, are out of the market entirely, thereby still further curtailing the foundry iron output. In the Buffalo district four large furnaces now are making basic iron that formerly operated exclusively on foundry grades. At Cleveland two furnaces were purchased by a large ore interest and while one of these stacks is still on foundry iron, it is reported that after July 1 the output of both will be taken by two independent steel interests. At Youngstown, O., two large furnaces that formerly made foundry grades were purchased by the Youngstown Sheet & Tube Co. and now are producing steelmaking iron. At Columbus, O., two foundry iron furnaces were taken over by the American Rolling Mill Co., Middletown, O., to supply the needs of its open-hearth furnaces.

This tremendous shrinkage in foundry iron production has taken place in the last 15 months. During the same period the growth of the foundry industry has been unparalleled in the history of the country. According to statistics gathered by THE FOUNDRY, 360 new casting plants were placed in operation since January, 1916. Hundreds of shops have increased their capacity. And in that same period it is estimated that the foundry iron producing capacity was reduced 1,200,000 tons by diverting the output of blast furnaces to meet steelworks requirements.

Foundry Iron Production Declines

Statistics gathered by the American Iron and Steel institute show a big falling off in the foundry iron production of the country during the first half of 1917 as compared with the same period the previous year. In the first six months of last year, 2,548,789 tons of foundry iron and ferrosilicon were made as compared with 3,086,410 tons in the first half of 1916, a decline of 437,621 tons. However, during the last six months production was increased as the total output for the year aggregated 5,328,258 tons. However, the decline in output the first half was too great to be overcome and the net decrease as compared with 1916 was 225,386 tons, or 4.06 per cent. In 1916 the production was 5,553,644 tons. During the nine previous years the output remained practically stationary, as the tonnage made in 1907 was 5,151,209. During the months of January and February the total pig iron ouptut of the country only aggregated 4,719,772 tons as compared with 5,809,774 tons during the same period in 1917, a decline of 1,090,002 tons. Approximately one-seventh of this loss was foundry iron or a total of 150,000 tons. On the other hand, malleable pig iron production has been increased in recent years with a total of 921,846 tons in 1916 and 509,946 tons in the first half of last year.

A number of blast furnaces now operating on foundry iron will change over to basic when their present contracts are filled. Most of these terminate about July 1 and it is at that time when the shortage will become more pronounced, unless immediate steps are taken to provide relief. Practically all of these furnace interests have contracted for ores to make steelmaking grades, and unless their future output now is diverted to foundry iron, it will not be possible to do so after the opening of the lake navigation season. It is the practice of the furnace interests to bring down their 12 months' ore supply and they must decide in advance whether the ore shall be for foundry or steelmaking grades. Within the next 30 days the foundry pig iron supply for a year will be definitely fixed and unless it is increased over the available tonnage and over what it will be after July 1, the foundries will be confronted with the greatest pig iron shortage in history and which will continue into next year.

Washington Should Inquire Into Nonessentials

While it is advisable for the authorities at Washington to inquire into the extent of the production of nonessentials by the foundries, it is equally advisable to scrutinize carefully the output of the steel works and rolling mills for products other than those required by the government.

A more equitable division of tonnage between the foundries and steel works should immediately be made. Today, foundries that are filling orders for projectiles, hand grenades, trench bombs, etc., are compelled to seek government aid to secure the iron for their needs. Of such requests that have recently been made, at least 90 per cent have been received from foundries and only 10 per cent from steel works. No better indication of the foundry iron scarcity could be cited.

Relief also might be obtained by increasing the maximum government price for foundry iron to enable small stacks to compete which now are idle owing to their inability to produce iron on the $33 basis. Licensing of pig iron requirements also has been recommended to enable the foundries to operate and to speed-up casting manufacture for the war program. The available supply of iron for all legitimate war needs should be ample and one class of buyers should not be preferred to another, because their case has been presented more vigorously at Washington and their need has been the more conspicuously presented from a military point of view.

Steel Foundries Short of Low Phosphorus Iron

INABILITY to meet the rigid specifications of the ordnance department, particularly as relating to the maximum phosphorus limit, is delaying the placing of contracts for thousands of tons of steel castings and manufacturers are demanding that the government make a slight concession in its mandate that phosphorus should not exceed 0.05 per cent. This request, it is pointed out, is not prompted by the inability of producers to meet this requirement, since it is representative of their practice in normal times. However, operating under the restraint of the present disjointed conditions, they say it is almost impossible for them to secure the necessary raw materials to meet specifications so rigid-

is drawn, and allowing such a minimum content.

The foundries affected are those operating acid-lined open-hearth steel furnaces and side-blow converters. The bulk of the tonnage of steel castings that is to be machined is made from acid steel and this metal also is used almost exclusively for medium and small work. Basic steel, on the other hand, enters largely into railroad work, although castings for locomotives and tenders largely are acid.

A pronounced shortage in the supply of low phosphorus pig iron and scrap has brought about the present situation and since there is no immediate prospect of its increase, the demand for a less rigid limit on phosphorus content has been made to the ordnance department. Within the past three years the low phosphorus pig iron producing capacity has been increased 80,000 to 100,000 tons annually by the Delaware River Steel Co., Chester, Pa., and the Thomas Furnace Co., Milwaukee. However, this tonnage, representing the most notable addition to the low-phosphorus pig iron production of the country in a decade, has not kept pace with the growth of consumptive needs. The greater part of the new steel foundry capacity that has become available since the beginning of the war is acid and many of the electric furnaces installed are drawing upon the limited supply of low phosphorus pig and scrap.

Low Phosphorus Output Increased

From Jan. 1, 1914, to Dec. 3, 1916, the production of low phosphorus pig iron increased nearly 200,000 tons. The output for 1914 was 306,569 tons, as compared with 501,213 tons in 1916. Unfortunately, figures for 1917 have not yet been compiled, but it is doubtful if they will show much of a gain over those of the previous year. The actual gain in low phosphorus pig iron production for 1914 to 1916 was 194,644 tons. During this same period the production of acid and converter steel castings increased 377,673 tons, or nearly twice the gain in the low phosporus pig iron output. Steel casting manufacturers present these facts as their best argument for more lenient phosphorus limits and it seems almost inevitable that their demands must be met if the government is going to obtain the large tonnage of steel castings so essential to the speedy prosecution of its war program.

In 1914 the production of steel castings by the acid open-hearth process was only 270,173 tons and during that year 65,882 tons of converter steel were poured, a total of 336,055. In 1916 the acid steel output of open-hearth foundries was 570,937 tons and that of side-blow converter plants, 142,791 tons, or a total of 713,728 tons. It is reasonably certain that the production of the acid steel casting plants in 1917 was greater than that of the previous year and with low-phosphorus pig iron output practically stationary, the cause for the present acute shortage of raw material for acid steel castings readily becomes apparent. In addition to the foregoing, the demand for low phosphorus melting stock for electric furnaces has increased tremendously. In 1914 only 8551 tons of electric steel castings were produced as compared with 42,870 tons in 1916. Last year the electric steel casting output made a tremendous gain owing to the large number of furnaces installed, although the figures have not yet been compiled. Electric furnaces, of course, may use basic pig, high phosphorus scrap or bessemer or open-hearth metal and they are not so restricted in their choice of raw materials as the acid open-hearth and the converter steel foundries.

Scrap Tonnage is Limited

In the figures giving the annual production of low phosphorus pig iron, that made from copper-bearing ore is included, thereby further restricting the supply of copper-free, low-phosphorus pig iron for acid steel castings for ordnance purposes. The low phosphorus scrap tonnage also is limited owing to the increased use of home scrap by the mills due to the general pig iron shortage. Latterly, the supply of this material has been cut off almost entirely by the car shortage and other transportation difficulties. In the readjustment of pig iron prices, the biggest reductions were made in low phosphorus pig iron and it is the prevailing opinion that if the government price had not been made, it would now be quoted at $200 per ton.

Ordnance experts contend that the maintenance of low phosphorus limits are absolutely essential owing to the low factor of safety on all parts entering into the construction of field implements of war. These must be constructed as light as possible and some sections have a safety factor as low as one, which must be contrasted with factors of safety of 5 and 10 to 1 in industrial operations.

Owing to the country's limited low phosphorus bearing ore resources, supplying the needs of the acid steel casting plants it is apparent will become increasingly difficult. The one solution to the problem that will afford immediate relief is that suggested by them, say the steel casting manufacturers. It provides for raising the phosphorus limit on government specifications. If greater leniency is allowed on ordnance work, it is believed that industrial users will fall into line and the proportion of low phosphorus pig iron in the charges may be slightly reduced thereby conserving the limited supply and making available a larger iron source.

Foundry Scrap Prices Are Changed

MODIFICATIONS of official scrap prices to equalize disparities between grades which had developed from the original schedules, and more complete definition as to the character of different grades are contained in the announcement of new iron and steel scrap prices and classifications, made by Chairman E. H. Gary, of the steel and steel products committee of the American Iron and Steel institute.

Some of the important changes put into effect by the latest announcement are, the reduction of the maximum price of No. 1 busheling from $35 to $32; the permission to charge $5 per ton for preparing cast scrap to cupola size; an advance of $5 per ton for cast iron borings and machine turnings for consumption in chemical plants; a reduction from $30 to $25 for heavy axle and forge turnings; an advance to $35 for malleable scrap for foundry use; fixing of a new grade of low phosphorus scrap at $35 a ton,

and of special sheared wrought iron at $40 a ton. No specific reference is made to the 3½ per cent commission which dealers in the past have been allowed over and above the maximum prices. The announcement is dated Feb. 21, when the new schedule became effective, and is as follows:

NO. 1.—NO. 1 HEAVY MELTING STEEL:

No scrap to be used for remelting into steel shall be dealt in at a price in excess of the maximum base, $30. This shall include all steel, wrought iron, cast iron car wheels, malleable scrap or other grades to be melted in basic open-hearth furnaces (except as noted in clauses 2, 3 and 4).

NO. 2.—LOW PHOSPHORUS STEEL SCRAP:

(a) To be used only in plants operating acid open-hearth furnaces, crucibles or electric furnaces. This grade, which shall consist of billet, bloom, bar and plate crop ends, axle butts and new mill plate shearings, ¼ inch thick and heavier, no piece to weigh less than 10 pounds, all in charging box shape and which will analyze 0.04 and under in both phosphorus and sulphur, may be dealt in at a differential of not exceeding $10 a ton over the base price of heavy melting steel. Maximum, $40.

(b) All other grades of low phosphorus steel scrap to be used in such plants, which will analyze 0.04 and under in both phosphorus and sulphur, may be dealt in at a differential of not exceeding $7.50 a ton above the base price of heavy melting steel. Maximum, $37.50.

(c) Special steel, for use in such plants, but which will not analyze under 0.04 in phosphorus and sulphur, may be dealt in at a differential of not exceeding $5 a ton above the base price of heavy melting steel. Such special steel shall include steel knuckles and couplers, rolled steel wheels, railway steel springs, carbon tool steel and similar material in quality and character, suitable for mills of this kind. Maximum, $35.

Note.—Material under this classification may not be dealt in for use by basic open-hearth plants using charging boxes at a price in excess of the maximum allowed for heavy melting steel ($30).

NO. 3.—STEEL RAILS AND STRUCTURAL SCRAP:

Steel rails, structural steel or similar scrap which has been especially sheared to short lengths for use in cupolas, hand charging furnaces or for rerolling purposes may be dealt in at a differential of not exceeding $5 above the base price of heavy melting steel. Maximum, $35.

Note.—Material under this classification may not be dealt in for use by basic open hearth plants using charging boxes at a price in excess of the maximum allowed for heavy melting steel ($30).

NO. 4.—OLD TEE RAILS:

Standard section old steel tee rails, free from frog, guard and switch rails, 56 pounds a yard and heavier, 5 feet and over in length, suitable for and to be used only for rerolling purposes, may be dealt in at a differential of not exceeding $5 a gross ton over the price of heavy melting steel. Maximum, $35.

NO. 5.—NICKEL STEEL:

Nickel steel scrap, excluding turnings, and containing not over one-half of 1 per cent of chrome, may be dealt in at the maximum price of heavy melting steel plus a differential of not exceeding $4 a ton per unit on the nickel content.

NO. 6—NO. 1 RAILROAD WROUGHT:

(a) No. 1 railroad wrought scrap may be dealt in at a price of not exceeding $35 a gross ton.

(b) When wrought scrap is especially sheared or prepared for piling or faggoting purposes to lengths of not under 10 inches or over 24 inches, it may be dealt in at a differential of not exceeding $5 a ton over the base price of No. 1 railroad wrought, but this may not include short wrought or other material which has not been especially prepared. Maximum, $40.

(c) Wrought iron railroad angle or splice bars, iron or steel shafting, suitable for rerolling, old iron rails, iron boiler plate cut apart in sheets and rings, wrought iron bridge scrap cut apart and similar wrought iron suitable for making sides and bottoms for box piling, may be dealt in at a differential of not exceeding $5 over the base price of No. 1 railroad wrought. Maximum, $40.

(d) No. 1 yard wrought, railroad track scrap and short wrought, also wrought iron and steel pipe, when 1 inch and over in diameter, 2 feet and over in length, free from dirty, painted, enameled or coiled and bent material, may be dealt in at a maximum of $1 a ton under the base price of No. 1 railroad wrought. Maximum, $34.

(e) The commodity known in the trade as No. 1 busheling scrap, when suitable for and to be used only by mills manufacturing bar iron, may be dealt in at a maximum of $3 a ton under the base price of No. 1 railroad wrought. Maximum, $32.

(f) Ungraded wrought iron and steel pipe and tubes, steel boiler plate cut apart in sheets and rings, country wrought and soft steel mixed, may be dealt in at a maximum of $5 under the base price of No. 1 railroad wrought scrap. Maximum, $30.

NO. 7.—RAILWAY AXLES:

Iron and steel railway axles, arch bars and transoms, old locomotive tires smooth inside and sheet bar crop ends, when suitable for and to be used only for rerolling purposes, may be dealt in at a differential of $12.50 a ton over the base price of No. 1 railroad heavy melting steel. Maximum, $35.

NO. 8—CAST IRON SCRAP:

(a) All cast iron scrap, whether broken or unbroken, including unbroken cast iron car wheels, may be dealt in at a maximum price not exceeding that of heavy melting steel, except as noted in clause b. Maximum, $30.

(b) Cast iron scrap in cupola shape, in pieces not exceeding 150 pounds, including broken cast iron car wheels, when suitable for and to be used only in cupolas or in puddling furnaces, may be dealt in at a differential of not exceeding $5 a ton over the maximum price of heavy melting steel. Maximum, $35.

(c) Malleable scrap of all kinds may be dealt in at not exceeding the maximum price of heavy melting steel. (Exception as noted in clause d). Maximum, $30.

(d) Malleable scrap in cupola shape, in pieces not over 150 pounds, when suitable for and to be used only in malleable works, may be dealt in at a differential of not exceeding $5 a ton over the maximum price of heavy melting steel. Maximum, $35.

Note.—Cast iron scrap or malleable scrap of any description may not be dealt in for use by basic open hearth furnaces at a price in excess of the maximum for heavy melting steel ($30). Maximum, $20.

NO. 9.—MACHINE SHOP TURNINGS:

(a) The term "machine shop turnings" shall apply to all grades of iron or steel turnings except as noted in clauses b and c.

(b) Heavy axle and forge turnings, or their equivalent, may be dealt in at a price of not exceeding $5 a ton over the maximum price of machine shop turnings. Maximum, $25.

(c) Nickel steel turnings containing not over one-half of 1 per cent of chrome may be dealt in at a price of not exceeding $5 a ton over the base price of machine shop turnings, plus a differential of not exceeding $4 a ton per unit on the nickel content. Maximum, $20.

NO. 10.—CAST IRON BORINGS:

This classification shall cover all grades of cast iron borings (except for the special purpose indicated in clause 3).

(a) Cast iron borings and steel turnings, when suitable for and to be used only by chemical plants or plants operating for purposes other than the remanufacture into iron or steel products, may be dealt in at a differential of not exceeding $5 above the base price. Maximum, $25.

All the above prices and differentials are per gross ton of 2240 pounds, and in all cases include all charges delivered f. o. b. cars.

(At the time of going to press it was reported that slight reductions in these quotations, effective April 1, might be ordered.)

Large Malleable Plant Nears Completion

PROBABLY the largest malleable cast iron foundry in the world, with an estimated daily output of 300 tons, built by the National Malleable Castings Co., Cleveland, will be placed in operation in the near future. This plant is the result of years of planning and study and its inception began with the initial development of a new system for making malleable castings. Here the iron will be melted by a triplex process, developed and patented by W. G. Kranz, vice president of the company, and it involves the application of the electric furnace to malleable cast iron manufacture.

The buildings of the plant upon which work has been progressing for a year, are located in a group and cover slightly more than 10 acres in extent. They include the foundry, machine, carpenter and pattern shops, boiler and power-house and service department. The erection of the office building will be undertaken at a later date.

The main foundry building in which the equipment for making castings by the Kranz process is installed, is an irregularly shaped structure, approximately 575 x 725 feet. The building is of steel frame construction, the outer walls being of brick, while the roof is of the Aiken type, covered with concrete slabs.

The structure is divided into bays or

aisles in which the various departments are located. The accompanying plan, reproduced from the February issue of the *Naco News,* shows the general layout of the plant. On the side adjoining the Belt Line railroad is the storage department, 75 x 575 feet. It is provided with a series of reinforced concrete bins for storing sand, pig iron, coke, limestone and other necessary materials. Fifteen freight cars can be accommodated in this bay at one time.

The melting department adjoins the storage department at about the middle of the structure. It is easily the most interesting feature of the entire plant. All the equipment necessary to the operation of the triplex process is located in this section. The equipment includes two cupolas, two 20-ton specially constructed heroult electric furnaces and two bessemer converters. Owing to the special nature of the product, however, only 15 tons of metal will be treated in the electric furnace each heat, despite the fact that they are 20-ton units. The melting capacity will be approximately 300 tons of metal per day, and the ladles of molten metal, holding from six to seven tons, will be transferred to the molding floors by means of electrically driven ladle cars.

Mr. Kranz's invention, described in his patent, is essentially as follows:

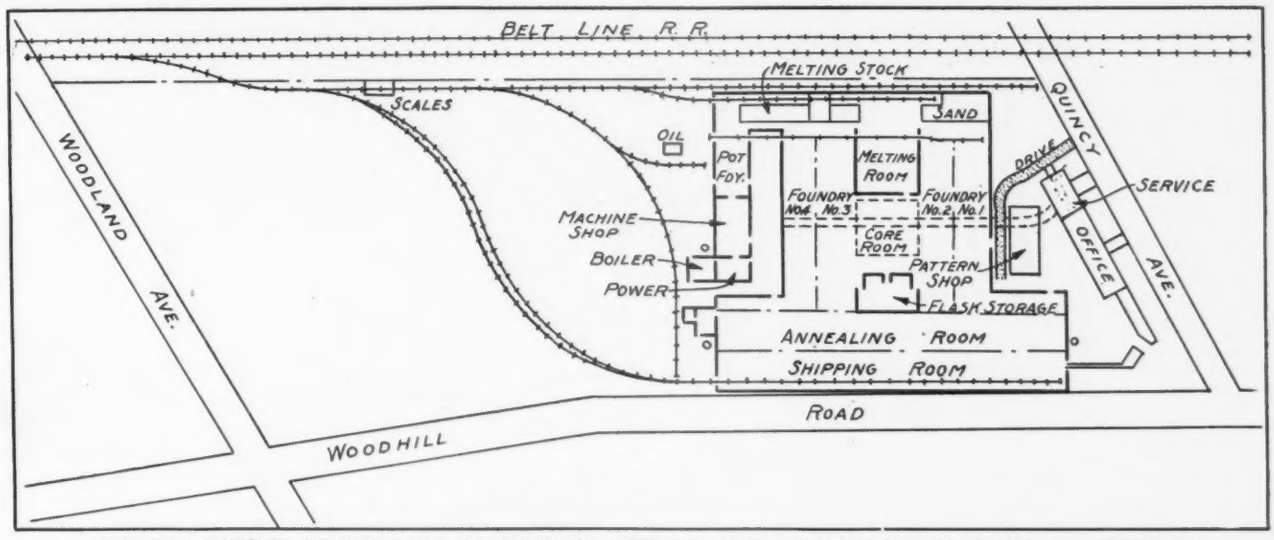
"My invention relates to the treatment of iron intended to be made into castings and is designed to overcome the difficulties resulting from the presence of relatively high carbon and also, in some cases, of relatively high manganese and silicon, but particularly of carbon, in the iron.

"In carrying out my invention, pig iron or scrap, or both, high in carbon, and which may contain appreciable percentages of manganese and silicon, are melted in any suitable furnace, such as a cupola, open-hearth, or air furnace. A portion of the melted charge depending on the amount of carbon and other impurities to be removed is then tapped out of the furnace and transferred to a bessemer converter, in which the carbon, manganese and silicon are wholly or partially blown out. The treated metal, and the remainder of the charge direct from the furnace are then poured into a ladle or other container with the result that the percentage of carbon, as well as the percentage of the manganese and silicon, in the complete charge, are reduced to within desired limits, and may then be cast. If a further refinement is desired, the charge may be transferred to an electric or other suitable refining furnace, in which the refinement of the metal is completed.

"I have found that with a charge of iron containing 3.25 per cent carbon satisfactory results can be obtained by taking one-fifth of the charge, introducing it into a bessemer converter and reducing the carbon to 0.50 per cent or less by treatment therein, so that when the treated metal is mingled with the remainder of the charge the percentage of carbon in the whole is approximately 2.70 per cent. After further treatment in an electric furnace the metal thus refined is extremely well adapted for malleable castings, and can be produced at a very much lower cost and in much less time than is the case when the reduction of the carbon is effected in either the melting furnace or in the electric furnace. If it is desired to produce gray iron castings, suitable additions, such as manganese or silicon, may be made in the vessel to which it has been transferred, and the charge may then be cast.

"The advantages of my invention will be apparent to those skilled in the making of iron castings, since the troubles arising from high percentages of carbon and in some instances, from high percentages of manganese and silicon, are practically eliminated, and iron containing excesses of such material is rendered commercially available for malleableizing and other purposes at a low cost and with a considerable saving in the time required for its conversion into castings. By the use of my invention it will be noted that the carbon and other substances may be reduced and equalized in any proportions depending on the character of the iron which it is desired to produce."

On either side of the melting room are two aisles, each 75 x 375 feet. These four bays or molding floors will be known as foundries Nos. 1, 2, 3 and 4. The basement and core room will be located between foundries Nos. 2 and 3, in a floor space, 125 x 175 feet.



GENERAL LAYOUT OF THE NEW FOUNDRY OF THE NATIONAL MALLEABLE CASTINGS CO., CLEVELAND

East of the core department and almost in the center of the building is a 4-story structure to be used for storing molding machines, flasks, boards and various foundry supplies.

At the eastern end of the four molding floors and at right angles thereto is the annealing department, 100 x 725 feet. For the present 12 annealing furnaces of unusually large size will be utilized. They will be equipped to burn powdered coal.

The shipping and finishing aisle, directly east of the annealing department has a floor area, 75 x 725 feet. It lies parallel to Woodhill road. The railroad tracks inside this department will take care of from 18 to 20 cars at one time.

The boiler and power house, 55 x 125 feet, is a steel and brick structure located at the southern end of the plant. The boiler room will contain three 350-horsepower water-tube boilers equipped with modern stokers. These boilers will be used for heating purposes only. In this department complete facilities have been provided for the handling and

storage of coal and ashes. A heating system with a forced circulation of hot water is being installed in all buildings. The electric power for the entire plant will be obtained from an outside source, and in the installation of electrical circuits throughout the plant all have been placed in conduits. The runs from the power room to the various points of use are all underground, and for this purpose alone over six miles of fiber conduits have been used, while about 12 miles of metal conduits will be installed above ground.

The machine and carpenter shop, which is of steel, brick and reinforced concrete construction, 75 x 120 feet, two stories, is located between and adjoins the annealing pot foundry and the power house. The first floor of this building will be used for the machine shop and the second floor for the carpenter shop.

The service building, a 3-story brick structure 50 x 90 feet, faces Quincy avenue at the north end of the plant. The workmen enter the plant from this building through underground tunnels which lead from the time clock lobby on the first floor to all departments. This building is designed primarily to be of service to the employes and contains the dispensary, locker rooms and shower baths, in addition to several large club rooms. Attractive quarters will be prepared for the workman.

Suggestions for Handling Stopper Heads

By A D Johnson

IMMEDIATELY after a supply of stopper heads is received from the manufacturer, a sufficient quantity should be unpacked to last for several weeks. These should be placed close to, or on top of the open-hearth furnaces where they will be subjected to a toasting heat until ready to be used. As rapidly as the supply is drawn upon, the stoppers should be replaced by others from storage. Drying in this way gradually eliminates the moisture that they may have collected in transit. The stopper rod man should have his work bench close to the open-hearth furnace where the stoppers are drying.

Assembling the Sleeves

After inspecting the rod and bolt head to see that they are clear of slag, the correct number of sleeve sections is placed on the rod and are pushed back to the goose neck. The bolt then is inserted in the stopper head and is clinched onto the bottom of the rod. The bolt head should be coated with a stopper mixture such as ganister or luting, or a moist mixture made by the Joseph Dixon Crucible Co., Jersey City, N. J. The recess in the stopper head then should be filled with ganister, completely covering the bolt head. The bottom section of the sleeve then should be brought down on top of the stopper head and a sufficient amount of stopper mixture should be placed between so that the surplus which is squeezed out can be used on the joint of the second section, and so on until the top is reached. Usually the stopper rod is provided with a large cap of approximately the same outside dimensions as the sleeve itself and this works up and down on the rod on a screw thread covering a distance of 3 or 4 inches. Between this cap and the upper section of the sleeve a coil wire spring is placed which surrounds the rod and should be sufficiently stiff to hold the sleeve sections firmly in place. At the same time, the spring should be flexible enough to allow for the expansion and contraction of the entire completed sleeve. The heat to which the spring is subjected is hardly sufficient to draw the temper, but this should be watched carefully. At the beginning, the tension should be light because when the hot metal surrounds the entire sleeve section, the sleeve will expand from ¼ to ½-inch and if provision for this expansion is not made, the strain is almost sure to force the stopper head from the rod at the bottom, or to crack one of the sleeve sections.

In some steel foundries it is the practice to pour in a ganister mixture at the top end of the sleeve after it is completed, thereby filling up all of the space between the sleeve and the rod down to the stopper head. After the rod has been assembled, it should be taken to a drying room provided with a circular, revolving rack suspended with the goose neck toward the floor. The reason for this is that whatever moisture is inside the sleeve will settle to the bottom and even with long drying, the stopper will not be in a proper condition if the moisture is permitted to run down all the time.

The Drying Process

In the drying room a fire should be built on the floor and should be maintained day and night. When the rod is placed in the ladle care should be exercised to have the stopper set properly in the nozzle and it should be moved up and down once or twice to prove this. Dry sand sprinkled around the stopper head where it fits into the nozzle after it has been seated for the first heat, will stop the flow of metal provided the fit is not perfect. If a stopper head cracks it is either due to the fact that not sufficient room for expansion has been left lengthwise of the sleeve or it is due to a bolt head which fits too tight in the stopper. If a stopper head scalps, this is due either to moisture or too rapid heating. If the stopper head washes before the metal, it usually is caused by an improper fit and when the leak starts, the wash of the metal gradually eats into the stopper head.

Swan & Finch Celebrate 65th Anniversary

The Swan & Finch Co., 165 Broadway, New York, manufacturer of oils and greases, recently celebrated the sixty-fifth anniversary of its organization. In February, 1853, this business was started in a small building at 44 Water street, New York, and so rapid has been its growth that today the main plant at Bayway, N. J., covers a tract of 15 acres, provided with piers at which tank and other ocean-going steamers dock. Originally the company engaged in the sale of illuminating oils and lubricants, such as were used in 1853, which consisted of fish and animal oils, sperm and other whale oils, sea elephant oils, black fish and lard oils. When the use of refined petroleum for lubricating purposes was discovered this company was one of the first to market mineral oils as lubricants and to manufacture lubricating greases with a mineral oil content. Among its other products is a combination of oils for core making in malleable and gray-iron casting work. Swan & Finch manufacture 197 different oils and greases which cover a wide range of mechanical purposes from the lubrication of airplanes to the manufacture of cores. The company has classified 103 industries in which one or more of its oils are used.

"Business Readjustment to War" will be the dominating note of the sixth annual meeting of the United States chamber of commerce, which will be held at Chicago, April 10 to 12.

How Iron Castings for Big Gun Lathes Are Made

Uncle Sam's War Program Includes the Production of Some of the Largest Machine Tools Ever Built and the Cast Parts Therefor Present Unusual Foundry Problems

By H Cole Estep

THE demands of the war on the foundry business are as extensive and varied as the numerous ramifications of the industry itself. Every avenue of the trade has been called upon to contribute its quota of productive energy. The makers of the lightest castings are finding that the army, the navy and the shipping board need their output. Producers at the other end of the scale, who specialize on massive, intricate castings for heavy tools and machinery have also been called upon to set aside a large share of their capacity to fill the needs of the hour. In fact in this branch of the business, on account of the size of the castings required, some unusually spectacular achievements have already been recorded.

Require Huge Castings

Our armies need quantities of the heaviest artillery and the manufacture of this artillery in turn requires the use of some of the largest and most powerful machine tools ever built. The foundries operated by the several builders of heavy machine tools in this country, therefore, have recently been called upon to turn out castings both in unprecedented sizes and quantities. In executing this work some unusual foundry problems have been encountered and solved.

One of the most widely-known plants in the United States devoted to the construction of heavy machine tools is the Niles works of the Niles-Bement-Pond Co., Hamilton, O. This foundry, which has been operated under the direction of Louis Baden, superintendent, for a number of years, is specially equipped for the production of large gray iron castings for fine machine tools. In fact it might be said the shop has been a center for this line of work for three or more decades. In making castings for heavy machine tools, such as large boring mills, lathes, planers, etc., more skill and ability is demanded than that required simply for melting and handling large masses of metal. Large machine tools for heavy ordnance work are instruments of precision that must work as accurately as shop equipment of smaller and more normal sizes. The castings used in the construction of these large tools, therefore, must meet certain standards of quality which are more severe than in many other lines of work. The metal must have maximum strength and homogeneity but at the same time must be easily machinable. The metal also should be uniform throughout the casting in order that the large bearing surfaces frequently employed may wear evenly. Large areas of these castings, often hundreds of square feet, have to be machined and unless the foundry work is executed with unusual care and precision heavy losses may be incurred through the partial machining of defective pieces.

Massive Lathe Beds

Among the many large castings now being made for war purposes at the Niles tool works, perhaps the most interesting are the beds, headstocks and tailstocks for 102-inch gun lathes. One section of a bed casting for one of these lathes is shown in Fig. 3. There are five such sections in the complete lathe bed. Three of them are 9 feet 10 inches wide and 39 feet in length, the other two being the same length but somewhat narrower. The partially completed mold for one of these sections is shown in Fig. 2. These castings weigh 75,000 pounds as they come out of the sand and 70,000 pounds when machined.

In making castings of this character certain general principles are involved which apply to practically all heavy machine tool work. As a rule the castings cover a large area, with comparatively little depth. Therefore,

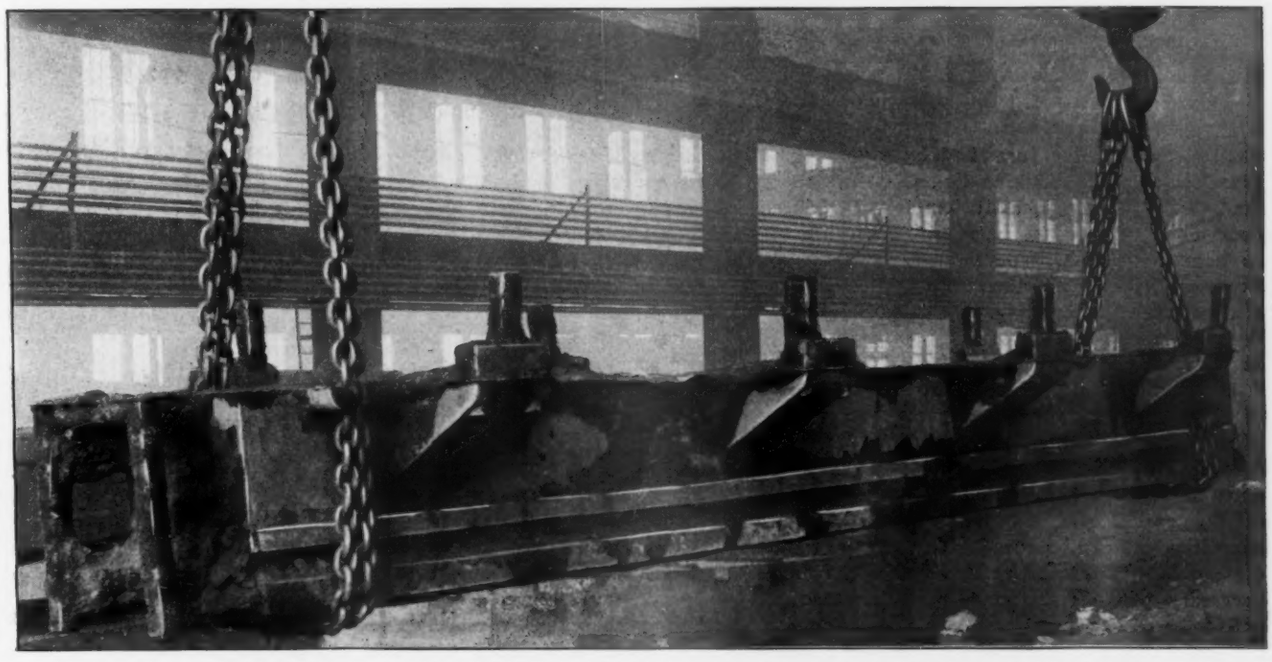


FIG. 1—BORING-BENCH CASTING FOR 102-INCH GUN LATHE WITH GATES AND RISERS ATTACHED

they are molded in shallow pits and since most of the castings are relatively flat only the plainest sort of cover copes are necessary. Sweeps of the simplest possible construction are used to form the drag portions of the molds.

Surfaces Require Care

The surfaces of these castings must be practically without blemish. Unusual attention, therefore, is directed to the facing sand. The natural facing sands which abound in the lower Miami valley are utilized. At the Niles works the sand is mixed mechanically in a machine furnished by the Standard Sand & Machine Co., Cleveland. The facing usually employed consists of 12 or 14 parts of sand to one of coal. Of course it is not necessary to use all new sand. Old and new sand mixed in equal proportions has been found most satisfactory. In extra large castings the facing is 2 inches thick, backed by floor sand of the usual character.

In addition to imparting a good surface to the casting, the sand should have an open structure to take care of the gas generated by the large quantities of metal poured into these big molds. For the same reason it is necessary to vent the cope carefully and to provide for the free exit of the gases in all directions.

It is impracticable to dry molds of the size required for the large castings made at the Niles Tool Works. It also has been found inexpedient to use loam. All of the work is done in green sand and in order to protect the mold surfaces they are thoroughly and carefully skin-dried. The drying process penetrates to a depth of about 1 inch, and the sand is particularly well baked for the first half inch. The molds are dried by means of oil-burning torches furnished by the Hauck Mfg. Co., Brooklyn, N. Y. Large flat molds, similar to those shown in Figs. 2 and 11, are covered with old corrugated sheets beneath which the flame of the torch is allowed to play during the drying process. This converts the mold into an oven thus drying all parts uniformly and effectively. It is customary to dry each mold all night.

Molds for castings such as those shown in Figs. 1 and 3 are carefully weighted to prevent any shifting during the pouring process. For this purpose large cast-iron blocks, 16 inches square and from 8 to 12 feet long are employed at the Niles tool works. These blocks are cast with short pieces of shafting in each end for convenience in handling by means of crane slings. Each block weighs from 5 to 9½ tons. Enough blocks are piled on each mold to hold the cope and casting securely in place. Usually from three to four times the weight of the casting is necessary. A pile of these weights is shown in the background of Fig. 2.

For the successful production of heavy machine tool castings it is necessary to pay particular attention to the character of the metal. If the metal is unsatisfactory the best molding practice in the world will not save the casting from the scrap heap. For castings of this character at the Niles tool works the cupola mixtures are proportioned to produce a metal containing approximately 1.70 per cent silicon, 0.10 per cent sulphur and 0.70 per cent phosphorus. Generally speaking, steel is not used in the mixtures. The customary 50-50 pig and scrap mixture is employed. Both No. 2 and No. 3 pig iron are utilized in the proportion of 70 per cent No. 2 southern iron running 2.25 to 2.75 per cent silicon and 30 per cent No. 3 northern iron running 1.75 to 2 per cent silicon. Both home and foreign scrap are used, the proportions varying with the production of scrap in the foundry. Care is exercised in purchasing scrap to insure a uniform quality.

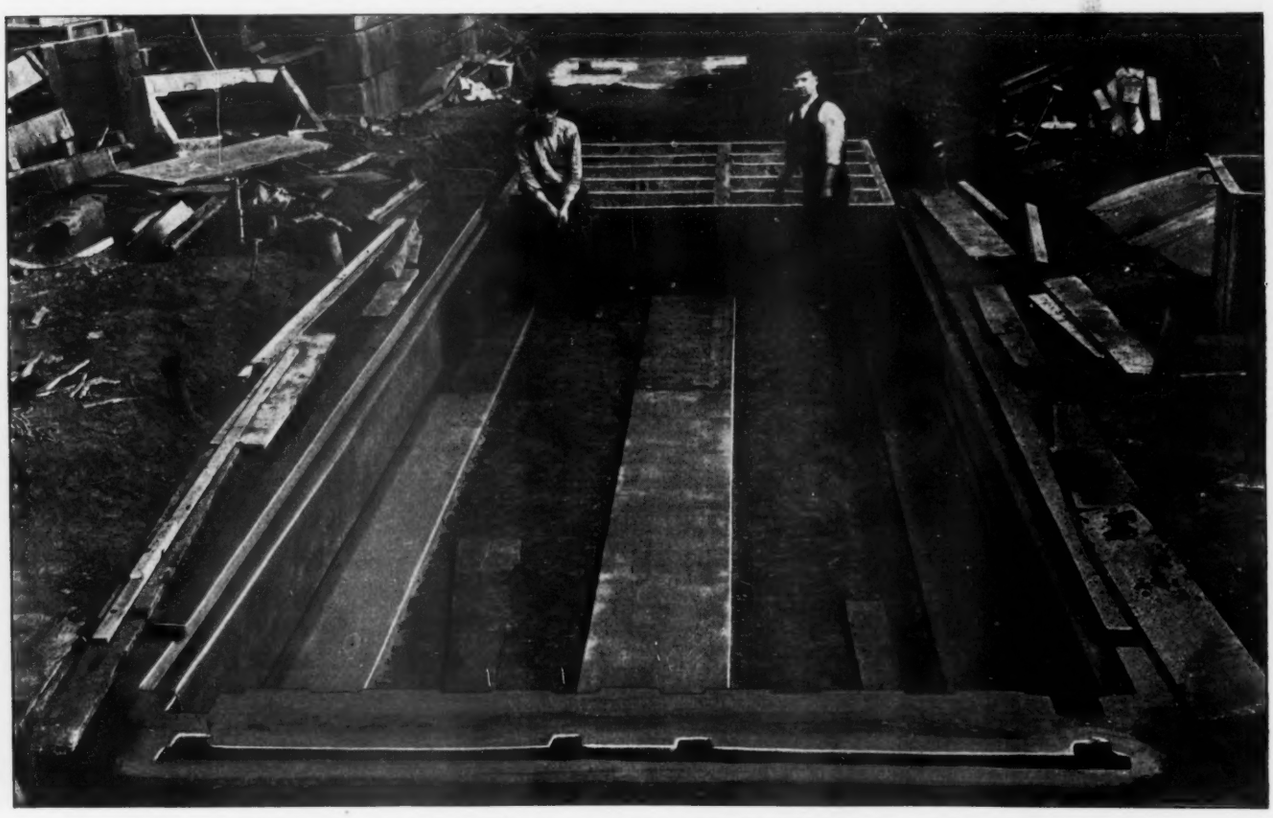


FIG. 2—SWEEPING OUT A MOLD FOR ONE OF THE BED SECTIONS FOR A 102-INCH GUN LATHE

Control Metal Quality

Mr. Baden believes in the practical control of the cupola operations by the results shown in the machine shop. For this reason he keeps closely in touch with the machining department and watches the progress of his castings through their finishing operations. Whenever any tendency toward hard-

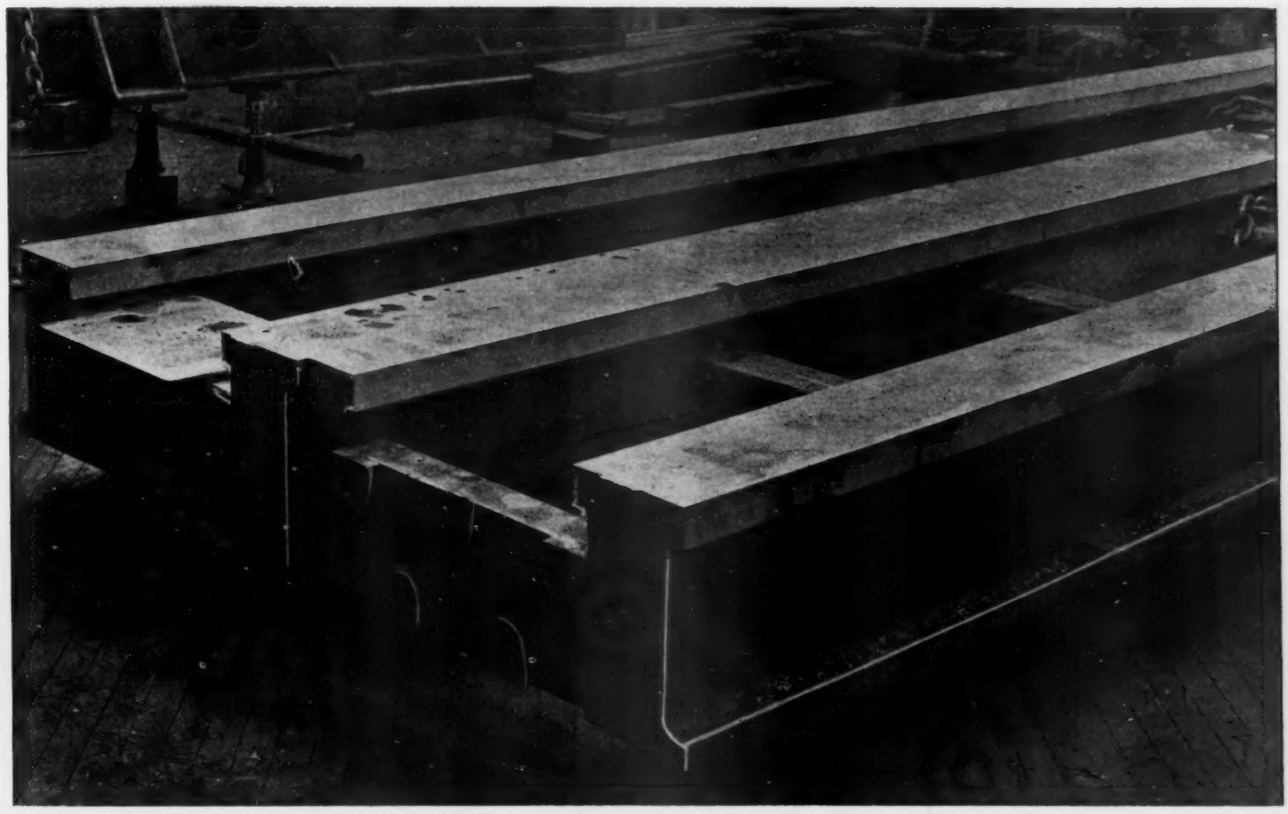


FIG. 3—ONE END OF A 70,000-POUND GUN LATHE-BED CASTING SHOWING GENERAL DESIGN AND THE CHARACTER OF MACHINING REQUIRED FOR FINISHING

FIG. 4—GUN LATHE-BED CASTING AS IT COMES FROM THE SAND IN THE FOUNDRY WITH RISERS ATTACHED—THIS CASTING IS A DUPLICATE OF THAT SHOWN IN FIG. 3

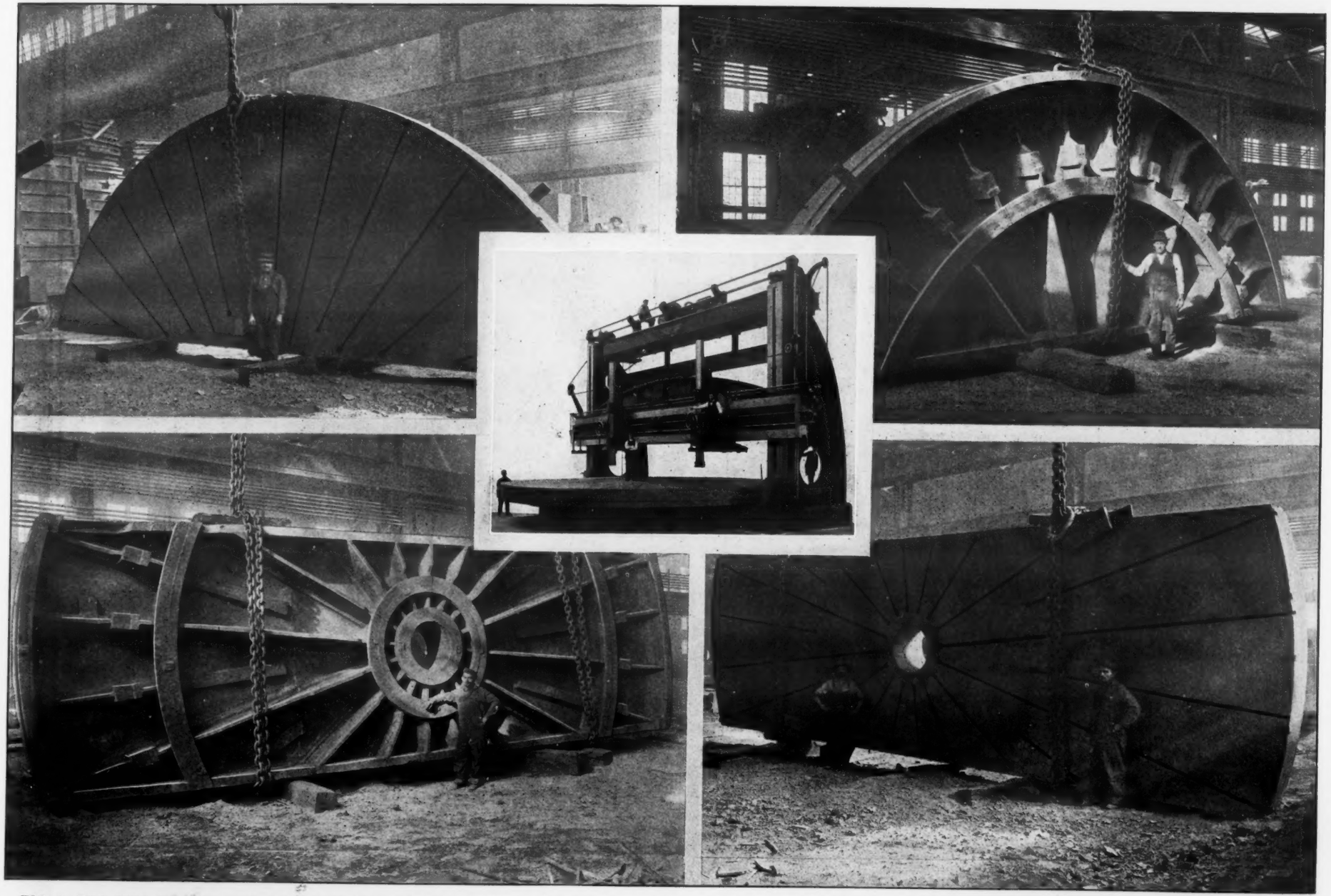


FIG. 5—TOP SIDE OF SIDE SECTION OF 34-FOOT BORING MILL TABLE FIG. 6—BOTTOM VIEW OF SIDE SECTION OF 34-FOOT BORING MILL TABLE FIG. 7—BOTTOM VIEW OF CENTER SECTION OF 34-FOOT BORING MILL TABLE FIG. 8—TOP VIEW OF CENTER SECTION OF 34-FOOT BORING MILL TABLE FIG. 9—THIRTY-SIX-FOOT BORING MILL MOUNTING 34-FOOT TABLE

ness or other unsatisfactory features appear they are immediately corrected before they become serious.

For large castings, such as those made at the Niles tool works, it is necessary to pour the metal as hot as possible and for this purpose the iron may be said to be superheated in the cupola. It comes out of the spout sizzling white hot, probably 2500 degrees Fahr., and on account of the large ladles employed, there is very little loss of heat between the cupola spout and the runners leading to the castings. In work of this character hot metal is the primary consideration to which coke consumption must be subordinated. Nevertheless, efforts are made at the Niles works to keep the coke consumption within satisfactory limits and for the three-month period ended Dec. 31, 1917, the melting ratio was 9.51 to 1.

As previously stated, the gun-lathe bed casting shown in Fig. 3 weighs 75,000 pounds in the rough and 70,000 pounds after machining. This casting is so large that ¾-inch must be allowed for finish on the machined surfaces. The metal sections range from 1 to 1½ inches. This casting is 9 feet 10 inches in width and 39 feet in length. It is that portion of the lathe bed which supports the headstock. The general arrangement of the mold, which is swept out to conform to the outside dimensions of the casting, is shown in Fig. 2.

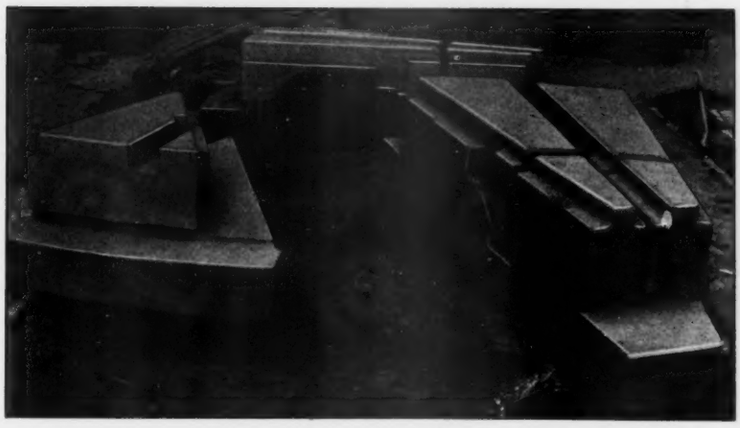


FIG. 10—A GROUP OF SEGMENT CORES FOR BORING-MILL TABLE MOLD

The flanges and webs of the three girders constituting the casting are formed by heavy dry-sand cores which are set in place after the drag portion of the mold is finished. Each core is made in an ordinary core box, rolled out on a plate and dried in an oven in the usual manner. The cores are properly rodded together and are filled with coke to insure free venting. In addition, a vent pipe extends up through the middle of each core. These pipes are so arranged that they come up through the joints in the cover cores forming the cope, thus affording a direct free passage for the gases from the interior of the mold to the atmosphere. These cores, which are merely large blocks of sand with suitable prints extending between the flanges of the castings on the drag side, are built-up on an iron foundation arbor of lattice or grillwork construction.

The cope for the gun lathe-bed mold consists merely of a series of flat cover-cores held in place by the large square weights previously described.

Fig. 4 shows the lathe-bed casting as it appears just after coming out of the sand. The rods used to reinforce the cores are illustrated and the method of gating also is clearly shown. The mold is gated at one end to bottom-pour runners which connect with the lower flanges of the casting. This insures the metal rising in the mold with the least tearing effect. At the same time any slight impurities will be carried to the top where they may be machined off. The arrangement of the gates, which are about 2 x 3 inches square, and the runners, is clearly shown in the foreground of Fig. 2. A pouring basin of suitable size is used in connection with the gate. There are four risers on each side of the casting as shown in Fig. 4. These risers are each 4 inches square and are joined to the upper flange of the casting. All of the work on one of these large molds is executed by two molders and a helper. Pneumatic rammers are employed extensively.

A heavy gun-lathe boring-bench casting as it comes from the sand is shown in Fig. 1. This bench rests on

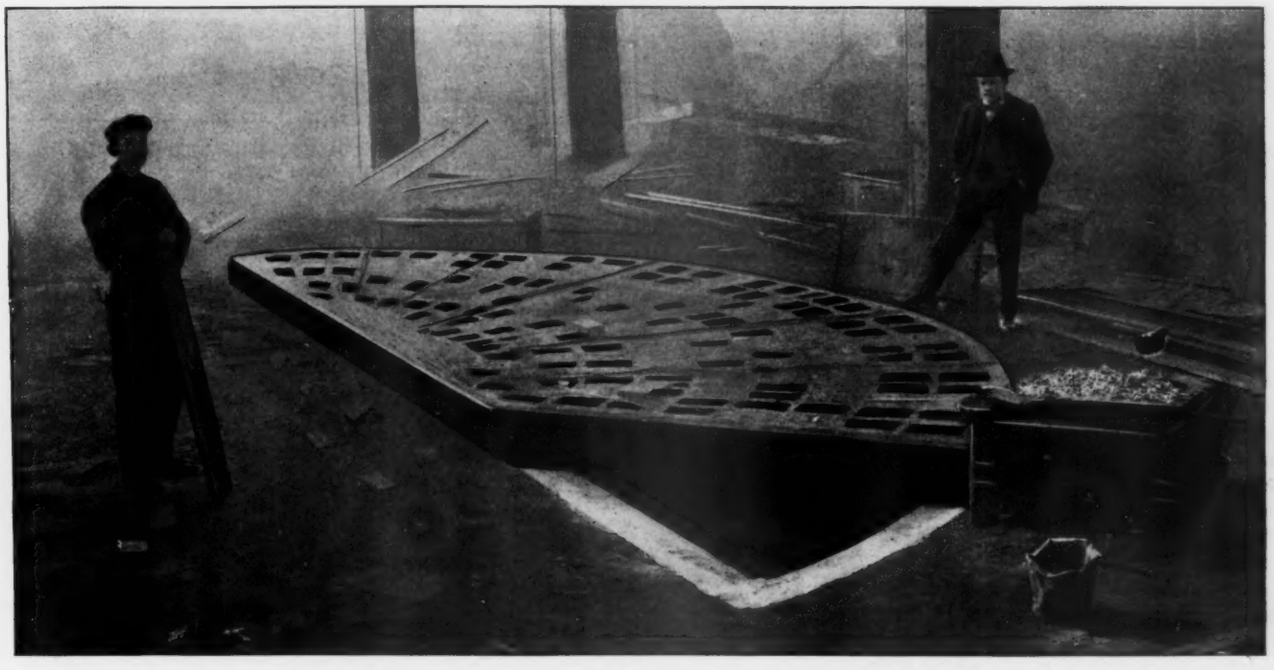


FIG. 11—BORING-MILL TABLE MOLD WITH SEGMENT CORES PARTLY SET

SIX-FOOT BORING MILL MOUNTING 34-FOOT TABLE

the bed of the lathe and supports the boring bar during the operation of finishing the inside of the gun. This illustration clearly shows the method of gating the casting and the arrangement of the risers. Two bottom-pour gates attached to one end of the casting together with eight risers are employed. This casting is made according to the principles previously described, the mold being swept in a pit with a sweep of simple construction. The flanges and sides are formed by dry-sand cores which are set in the drag portion of the mold after it is completed.

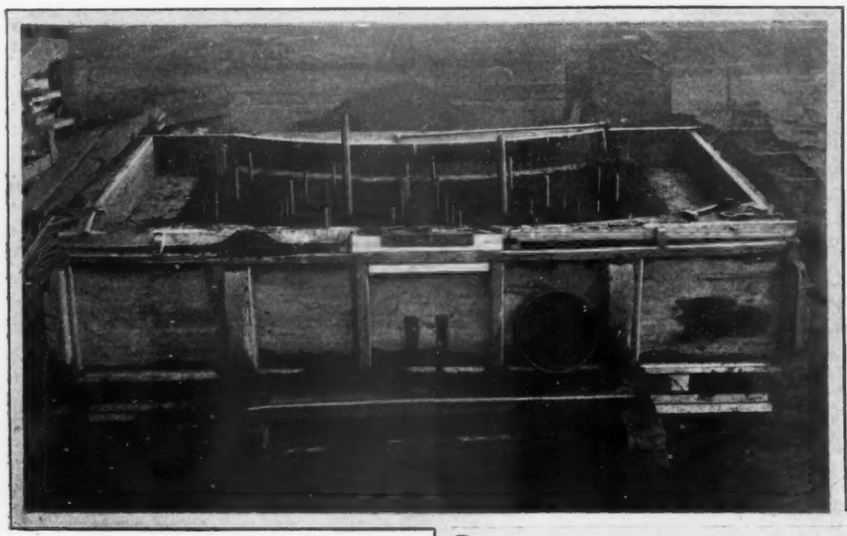


FIG. 12—CORE BOX FOR BORING-MILL TABLE CORE

Casting Large Boring Mill Tables

Some of the problems to be solved in casting a large boring-mill table are suggested by Figs. 5, 6, 7 and 8, which show sections of a 34-foot table for a 36-foot boring mill. Owing to transportation difficulties, the table is cast in three sections, including a center section and two side segments. The top and bottom sides of the center section, which weighs 83,000 pounds, are shown in Figs. 7 and 8, while Figs. 5 and 6 show the corresponding sides of one of the side sectors.

The method of making one of the molds for this work is illustrated in Fig. 11, which shows a mold for a 102-inch tire mill. Like the gun-lathe mold, previously described, these molds are made in a pit using a plain cover core. The necessary ribs and configurations on the under side of the table are formed by core segments similar to those shown in Fig. 10. These segments are assembled in the mold as shown in Fig. 11. One of the core boxes employed on this work is shown in Fig. 12, which also illustrates clearly the method of making the core. This core is provided with eight rows of rods and two vent pipes. It is rammed by hand using core sand of standard composition. The total weight of the three parts of the table for the 36-foot boring mill, as they come out of the sand in the foundry, is 240,000 pounds, or 120 tons. The reason for the segments is obvious. The melting equipment is an exceedingly important part of the Niles foundry inasmuch as it furnishes the metal required for the extra large castings that are continually made in this shop. Mr. Baden states he has run 130-ton heats in a single day and could if necessary run 350,000-pound heats. Three cupolas are provided, 48, 60 and 68 inches in diameter inside of lining, respectively. They were built by the Calumet Engineering Works, now a part of the Whiting Foundry Equipment Co., Harvey, Ill. These cupolas are rated at 7, 11 and 15 tons per hour respectively, figuring from the time the wind goes on to the end of the heat. Under ordinary circumstances the smallest cupola is used only as an auxiliary or for small, special heats. Fairly heavy charges are employed, the metal charges for the three cupolas being 3000, 4000 and 5000 pounds, respectively. A 6000-pound bedcharge is placed in the 68-inch cupola; the bed charge in the 60-inch cupola is 4700 pounds and that in the 48-inch cupola, 3500 pounds.

In order to handle the large amounts of metal melted every day, special yard equipment has been provided. The supply yard, which is immediately adjacent to the building, is 91 feet wide and 450 feet long. It is served by two 10-ton Niles cranes with trolleys protected from the weather. These cranes are employed to transfer the charges from the yard direct to the charging platform, as indicated in Fig. 13. The interior arrangement of the charging platform, together with the scale and charging car, is shown in Fig. 14. This platform is of standard construction. Parallel to the supply yard is a storage yard of equal size where large numbers of flasks and heavy castings are stored. It is equipped with a 25-ton crane.

FIG. 13—GENERAL ARRANGEMENT OF SUPPLY YARD SHOWING TRAVELING CRANE SERVING CHARGING PLATFORM

The metal is handled from the cupolas to the molds in two 25-ton ladles, each of which will pour 45,000 pounds clean. The ladles are handled by the foundry cranes and also by small Jeffery storage-battery trucks similar to that shown in Fig. 15. This also indicates the general arrangement of the melting department.

The main bay of the foundry, which has a span of 60 feet, is served by three 30-ton Niles cranes and two 3-ton traveling jibs. The side bay which is 60 feet wide, is served by four 10-ton traveling cranes and four 3-ton jibs. Both the center and side

bays are 450 feet in extreme length.

Some of the smaller castings made in this foundry, which would be unusually large in an ordinary shop, are molded on a jar-ramming machine of 35 tons capacity furnished by the American Molding Machine Co., Terre Haute, Ind. In addition, several other molding machines of various kinds are provided for smaller miscellaneous work.

Bridging of a Small Cupola

By W. J. Keep

Question:—Our cupola is lined to 34 inches and is provided with six tuyeres, 8 inches wide and 6 inches high. These are located 10 inches above the sand bottom. Another row of six tuyeres is located 14 inches above the lower tuyeres and these are 4 inches square. After melting about six tons of iron, the flow of metal is retarded and a bridge forms about 14 inches above the upper tuyeres. The iron runs into the lower tuyeres and slag flows out of the tap hole. More iron than slag flows out of the slag hole and, therefore, we have discontinued the practice of slagging. About seven tons of iron per heat is our limit, but we are anxious to melt more iron. Our heats last about two hours and 15 minutes. We charge 20 pounds of limestone on each charge after one-third of the heat is off. Also, the lining burns out quickly.

FIG. 14—CHARGING PLATFORM SHOWING ARRANGEMENT OF SCALE AND CHARGING CARS

Answer:—You are doing remarkably well with a cupola of this size and you are operating your furnace at capacity and may expect bridging if you melt more than six tons. I suggest closing the upper tuyeres. If you do not use the slag hole, only charge limestone on the last three charges. However, you must learn to use the slag hole. This should be located below, but between any two tuyeres, but never have a tuyere directly above the slag hole. Start the slag running as soon as possible. Never let the iron rise high enough to run out of the slag hole, which in your case is too low. The lower tuyeres should be 12 inches above the sand bottom and the slag hole should be raised with them. Your troubles will cease when you learn to slag properly and you then should be able to melt more iron. Limestone has a tendency to eat away the lining, and you should use only enough to give a fluid slag. The bed should be about 18 inches above the lower tuyeres when you begin to charge iron, provided the upper tuyeres are closed. Do not make any changes other than suggested until you obtain good results and then you may reduce your iron charges to 1000 pounds or even less and reduce the coke charges to 100 pounds or slightly more. Avoid charging dirt in any form and never charge the sweepings from the cupola platform. Break the scrap as small as the pig iron. Your blast pressure is too high for a cupola of this size.

Eye Hazards in Industrial Operations

The chief industrial hazard to eyesight in the industries of the United States are discussed in a 150-page volume, published by the National Committee for the Prevention of Blindness, New York. It was compiled by Gordon L. Berry, field secretary of this committee, with the co-operation of Lieut. Thomas P. Bradshaw, formerly technical assistant to the director of the American Museum of Safety. Case reports illustrate each section, special dangers are described and recommendations are made for such changes of working conditions, or installations of protective devices as have been found suitable for protecting workers. The following sectional headings indicate the scope of the book: Statistics of eye accidents, shipping operations, machine operations, abrasive wheels, sand-blasting, mushroomed tools, riveting, radiations from intense light and heat sources, ultra-violet rays in illuminants, radiant energy in arc-welding and in molten metal, metallurgic operations, glassblowers' cataract, infections, gage glasses, acids and chemicals, treatment of acid burns, industrial poisons, removal of dangerous fumes, vapors and gases, spray process hazards, methyl alcohol, bottling accidents, mining and quarrying, agricultural hazards, goggles, garment trade hazards, industrial lighting and the safety movement.

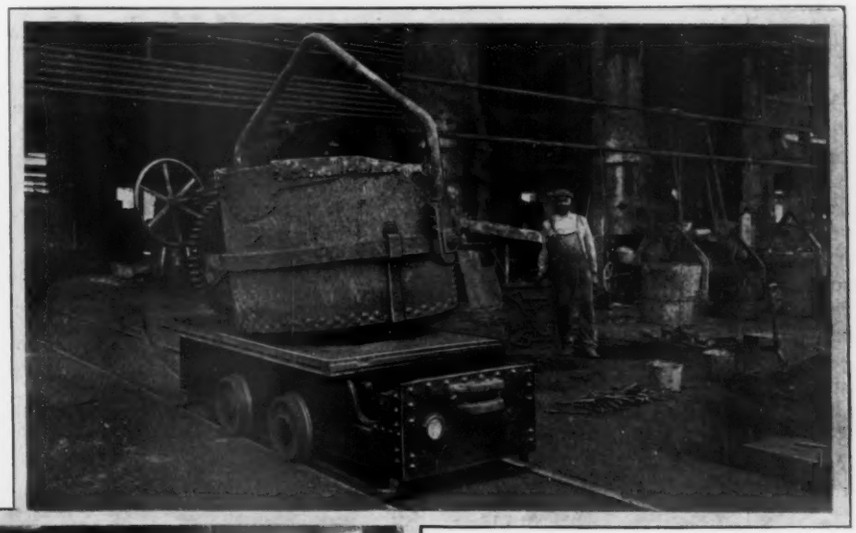


FIG. 15—MELTING DEPARTMENT SHOWING LADLES AND STORAGE BATTERY TRUCK

A new metal crucible, recently patented and intended for the melting of copper, brass and bronze, consists of an alloy of chromium, 12 parts; nickel or cobalt, 60 parts; iron, 26, and manganese, 1.5 parts.

Annealing By Muffle and Pot Ovens Compared

The Carbon Losses By These Two Methods of Treating Malleable Iron Are Discussed and Test Results Are Presented

By Joseph B Deisher

WE know that carbon in any ferrous metal must exist in the form of combined carbon or graphitic carbon, or both. To go a step farther, we must admit that, after all, it is principally the proportion and condition of the carbon present which determines in what class we shall ultimately define such metal, that is, whether we shall call it wrought iron, steel, malleable iron, or gray iron. Therefore, it seems hardly necessary to state that the vital importance of carbon in malleable iron cannot be overestimated. However, the limitation of my subject does not invite any prolonged discussion of this element except as it is affected by the annealing process.

Combined carbon represents a condition where practically all of the carbon present has, due to certain laws of metallurgy, gone into solid solution with iron, forming iron carbide, or, in malleable practice, what is generally known as hard iron. Had the greater part of the carbon not gone into solid solution, an ordinary gray iron casting would have been the result, representing a composition of free graphite, combined carbon and pure iron. Here, the carbon would largely exist as graphitic carbon. The former represents a proper composition for annealing while the latter does not possess the requisite physical properties.

Annealing Process Defined

Then, we may consider that the annealing of malleable cast iron consists of heating a hard iron casting of the proper chemical composition to a degree of temperature where practically all of the iron carbide is dissolved from solid solution, without subsequent fusion, after which the casting is allowed to cool to handling temperature, 150 to 300 degrees, Fahr., under conditions that will permit the carbon to precipitate as minute graphite deposits in a texture of practically pure iron. In other words, the annealing process is simply a precipitation or conversion of carbon which had previously been driven into solid solution with iron; but, this conversion is most always accompanied by a loss of carbon, and it is this removal of carbon that later on we are to discuss. As briefly outlined herein, the annealing process seems very simple; yet, there are many conditions that may interfere with the perfect conversion of the carbon, some of which we will discuss in the following order: Hard iron composition; annealing temperatures; time required to dissolve iron carbide; rate of cooling; and removal of carbon in the anneal.

Presented at the Boston convention of the American Foundrymen's association.

Hard Iron Composition

In the first place, the analyses of the hard iron composition must come within certain specified or ratio limits or the iron carbide will not completely dissolve under ordinary annealing temperatures. To establish these limits is not the purpose of this discussion. For the sake of brevity, we must assume that they are known. However, it might be appropriate here to state that a hard iron composition figured on the silicon alone is no better than guesswork, so far as obtaining uniform physical results in the annealed product is concerned. In fact, the most uniform results can obtain only where we know with some degree of accuracy the total carbon content in the hard iron, and such knowledge is not readily available without the total carbon analyses of the pig iron, which, due to its high and variable carbon content, determines the percentage of the various grades of scrap material that can be carried in the melting mixture. Blast furnace operators are reluctant to furnish or guarantee the carbon analyses of pig iron, which is a matter of such vital importance to the successful production of high-grade malleable iron castings that I hope it will merit thorough investigation by a thoroughly competent committee.

Annealing Temperatures

In the matter of annealing temperatures for malleable cast iron, much depends upon the chemical composition of the hard iron. Ordinarily, the iron carbide commences to be slightly affected after the temperature has reached approximately 1250 degrees Fahr., but the chemical union forming the carbide is not greatly weakened until a temperature of at least 1400 degrees is reached. In fact, it is, for many reasons, desirable to run the temperature considerably higher than 1400 degrees. The following table shows what may be considered safe maximum and minimum annealing temperatures for both pot and muffle type ovens:

	Maximum degrees Fahr.	Minimum degrees Fahr.
Pot oven	1650	1450
Muffle oven	1700	1500

Exhaustive tests have shown that prolonged annealing has no detrimental effect upon the physical strength of the product, unless the temperature is run too high, in which case troubles, too numerous to mention, may result. Prolonged or repeated annealing at high temperatures, however, will have a growing tendency to produce a pearlite rim, which seriously interferes with machining operations, but the unreasonable length of time required to produce the rim, under normal annealing conditions, eliminates this as a disturbing factor. Therefore, it would seem only reasonable to assert that when malleable cast iron is seriously over-annealed it is usually because the temperature has been run too high rather than too long. However, on the other hand, it is, I believe, also a safe assertion to state that so far as annealing is concerned, more poor-grade malleable cast iron is produced as the result of under-annealing than over-annealing. If the temperature limits given are adhered to and good results do not obtain the trouble is not directly due to annealing temperatures.

Heat Distribution

Heat distribution sometimes brings up a troublesome problem, the difficulty being to reach the minimum temperature at the coolest point in the oven without exceeding the maximum temperature at the hottest point. This is largely a matter of oven design, and unless any two points in the oven can be held within the limits herein prescribed, there is something radically wrong with the oven, or the manner in which the burden is arranged. The trouble might be that the flues are not clean.

For reasons not generally understood, it has been found necessary to hold castings at annealing temperature from 60 to 72 hours before the cooling process is commenced. Otherwise, the result will almost invariably show that the iron carbide has not been completely dissolved; that is, the annealed casting will show that a portion of the carbon remains in solid solution, as combined carbon, causing a brittle, inferior product unfitted for further operations.

It would seem probable that the chemical union forming the solid solution of carbon in iron is not thoroughly dissolved immediately after the annealing temperature has been reached, or, if the iron carbide is completely dissolved in less than 60 hours, we have yet to discover the means of preventing a portion of the carbon from re-combining when the casting is cooled to handling temperature. Then, assuming, for the sake of argument, that it has been found necessary to hold the castings at annealing temperature for 60 hours, three questions arise which should invite interesting discussion, namely:

1.—Are 60 hours actually required to dissolve the iron carbide?

2.—Does the iron carbide dissolve in less than 60 hours, the balance of the allotted time being required for precipitation of graphite carbon?

3.—Does the precipitation of graphite carbon immediately follow the gradual dissolution of the iron carbide, requiring 60 hours to complete the conversion process?

I would answer the first question negatively. It is my opinion that dissolution of the iron carbide is largely a matter of heat penetration, particularly where the muffle type oven is used. In the pot oven, there is little doubt but that the nature and composition of the packing material affects the dissolution of the iron carbide, which assumption is in part at least borne out by the fact that malleable annealing can be successfully conducted with this type of oven at approximately 50 degrees lower temperature than is required in the muffle oven. This does not necessarily mean that the temperature at which the iron carbide is affected in the pot oven is lower than in the muffle oven. In the pot oven, after say 1400 degrees temperature is reached, it would seem that the effect of the oxide packing material tends to hasten the dissolution of the carbide at a lower ultimate temperature than is required in the muffle oven. In other words, I believe that by skillful manipulation of oven temperatures, the iron carbide can be dissolved in less than 60 hours after annealing the temperature has been reached.

Dissolving Iron Carbide

In regard to the second question, I am inclined to believe that the iron carbide can be dissolved in less than 60 hours, and that it is the obstinate or lagging precipitation of graphite carbon, at the usual annealing temperature, that delays the conversion process, under present practice. Then, assuming that such is the case, the question arises as to the state of the carbon between dissolution and precipitation. In my opinion, after the annealing temperature has thoroughly penetrated the entire body of the hard iron casting, the chemical union forming the iron carbide is so weakened that the rate of cooling determines whether the carbon will remain in solid solution as combined carbon or will precipitate as graphite carbon. In other words, after dissolution of the iron carbide, I believe that the carbon exists in a semisoluble state, from which it will precipitate as graphite if cooled under proper conditions.

It is doubtless unanimously agreed that the third question covers, in a general way, about what really happens. In fact, practical tests have shown that where test wedges were removed from the oven at regular intervals before 60 hours had elapsed after the annealing temperature was reached, combined carbon was almost invariably found to exist in direct proportion to the length of time the wedges were held at or above annealing temperature. However, this does not prove conclusively to me that 60 hours are actually required to completely dissolve the iron carbide. On the other hand, I am inclined to believe that in the test wedges just referred to the annealing temperature had not completely and uniformly penetrated the entire body of the metal and also in removing the wedges from the oven before the regular period for annealing was completed the cooling was too rapid. In other words, had the annealing temperature been as high as the castings would stand at the beginning of the anneal and the wedges that were withdrawn before 60 hours of annealing had been completed, cooled very slowly, the results would doubtless have shown that a greater percentage of the carbon had precipitated as graphite.

An Interesting Occurrence

In this connection, I recall an incident where by accident the arch forming a muffle chamber in a muffle type oven fell in and the fire had to be shut off about 36 hours before the regular time. The stack damper and the oven were sealed up practically air-tight and allowed to cool down as slowly as possible, with the result that when the oven was opened the castings were found to be fairly well annealed. The carbide appeared to be completely broken up, but there were scarcely a trace of decarbonization visible without the aid of a microscope. This condition I attribute to the fact that the annealing temperature was high when the accident occurred and the cooling was extremely slow, allowing plenty of time for the precipitation of graphite. It might also be of interest to know that the castings were not scaled. Professor Touceda has done some very enlightening research work along this line, but it has occurred to me that some of the conclusions he has arrived at in regard to the length of time required to break up the iron carbide, may, after further experiments, be altered by the effect of higher initial annealing temperature and slower rate of cooling. It should be thoroughly understood that I take no exception to the conclusions he has reached, based upon the experiments as they were made.

We must realize that one of the greatest drawbacks to the malleable industry is that it takes too long to anneal the castings. While my experience in malleable annealing has not gone far enough to justify any revolutionary results, there is no doubt whatever in my mind, but that the time required under present practice for this operation can be very materially reduced. To that end, if the presentation of this paper stimulates discussion and exchange of opinion regarding the points brought up, its purpose will have been accomplished.

Rate of Cooling

Aside from the absolute necessity of first completely dissolving the iron carbide, the rate of cooling is, in my estimation of the utmost importance, particularly where it is desired to complete the annealing process in the shortest time possible.

It is generally considered that the sooner the castings can be brought to annealing temperature, the better; but the same rule does not hold true in the matter of cooling to atmospheric temperature after the annealing temperature has been reached and held for the required time. After the iron carbide is dissolved, the object then is to cool the oven under such conditions as will prevent recombining of the carbon. If cooled too fast, all the carbon will not precipitate as graphite.

Practical tests have shown that the recalescence point in cooling malleable cast iron from annealing temperature is slightly under 1400 degrees Fahr. Plotted cooling curves have shown that at this temperature there is an abnormal liberation of heat from some source, presumably the result of rapid precipitation of carbon, first as graphite, then as carbon monoxide and carbon dioxide gas, depending upon the amount of oxygen present; hence, the ultimate removal of a portion of the carbon, as will be mentioned later. Therefore, we will establish 1390 degrees Fahr. as the critical point in cooling for annealing malleable cast iron, that is, the point in annealing at which graphite will precipitate with most rapidity.

Holding at Critical Point in Anneal

It is held by some authorities that, after the iron carbide is completely dissolved, the castings should be held at or slightly above the critical point in cooling for several hours in order that the precipitation of graphite carbon may be more complete, the theory being that graphite carbon will precipitate with

more rapidity the nearer the critical point just referred to is approached. Contrary to such theory, it is the practice of some foundrymen to run the temperature to the highest point just before the fire is shut off; then seal up the oven and, as they express it, "allow the castings to soak." To my mind, such practice is quite the reverse of what it should be. In other words, I am inclined to believe that the nearer the temperature of 1400 is reached in cooling, the more favorable become conditions for the precipitation of graphite carbon, providing, of course, the temperature has previously reached the point where all iron carbide was dissolved. Therefore, it would seem the better practice to reach the highest temperature at the beginning of the anneal, such temperature to be held until the iron carbide is dissolved; then, gradually drop to 1400 degrees, a temperature which some believe will better favor the precipitation of graphite carbon. This would also lessen the danger of warping. In fact, I would not be at all surprised that, when the temperature is run high at the end of the anneal, some of the carbon is, due to being more nearly soluble in iron and lack of time in cooling, forced back into solid solution as combined carbon which would otherwise have precipitated as graphite had the temperature not been run so high just before the cooling process was commenced. In some cases, where the sulphur-manganese ratio may not be properly balanced in the hard iron composition, such practice is also much more apt to produce a pearlite rim or *picture-frame* fracture, a source of extreme annoyance where the castings have to be machined. However, this condition is rarely, if ever, produced by annealing alone, except where the annealing is prolonged almost indefinitely or the temperature run entirely too high.

Graphite Carbon Precipitation

A feature which might have been mentioned in connection with establishing the critical point in cooling is that, while approximately 1390 degrees represents the point in temperature at which graphite carbon precipitates with most rapidity (assuming, of course, that the iron carbide has been dissolved by subsequent heating at higher temperature), it does not necessarily follow that the precipitation of graphite ceases immediately the temperature drops below 1390 degrees. In fact, the precipitation of graphite carbon, in some cases may continue until the temperature drops to 1242 degrees, below which temperature all precipitation is arrested. Therefore, in reality, 1242 degrees is the critical point for dissolution of the iron carbide; or, in other words, this is the temperature at which the chemical union forming the carbide commences to weaken upon heating and is also the point at which the precipitation of graphite carbon ceases upon cooling. Malleable iron annealing could not be successfully conducted at either 1390 or 1242 degrees temperature, if at all, due to the length of time that would be required to dissolve the iron carbide; and, therefore, these temperatures are extremely important only in the matter of cooling the castings from annealing to handling temperature.

Cooling From Critical Point

As to the effect of further cooling between the temperature of 1242 degrees and handling temperature of the castings, this, I believe, depends solely upon the condition of the carbon when the temperature of 1242 degrees in cooling was passed. Where combined carbon is present, the effect of the rate of cooling upon that part of the structure representing the carbide would be about parallel to the tempering of a piece of soft steel of the same carbon content, heated and cooled under similar conditions. In other words, the more rapid the cooling, the harder would become the crystallization of the carbide and, consequently, the more brittle the casting; and, *vice versa*. Were all the carbon in graphitic form at 1242 degrees, the cooling might be forced to handling temperature without detriment to the physical characteristics of the metal. This is based upon the theory that iron and free carbon are not readily, if at all, soluble at 1242 degrees Fahr.; therefore, the formation of iron carbide is impossible, and where there is not combined carbon present in ferrous metal it can usually be hardened very little by tempering. As a practical test a well-annealed malleable test wedge was heated in a hand-forge to a cherry red and quenched in cold water, without the slightest effect upon the ductility of the metal or condition of the carbon. Then, a duplicate wedge was heated to a slightly higher temperature and cooled under the same conditions, with the result that the carbon was re-combined and the metal very brittle, showing a steely, white fracture. In the first test the critical point was not reached where the iron and free graphite were soluble; and, as practically no carbide was present to commence with, the metal was not hardened to any noticeable extent by temperature. In the second test it would seem that the temperature was reached where the free graphite became dissolved in iron and by sudden cooling through the critical range was forced into solid solution as combined carbon, which composition was still further hardened by tempering.

The point which I wish to make clear is that where conditions have been ideal for conversion of the carbon, more liberty can be taken in cooling the castings from 1242 degrees Fahr. to handling temperature, thus saving considerable time at present allowed for gradual cooling through the same range of temperature.

It is possible to accomplish the conversion or annealing process without removing any carbon, but, as this is neither practical nor desirable, it will not be discussed. The removal of carbon is entirely the result of oxidation; and, where no oxygen is present, no carbon can be removed. Oxygen for the removal of carbon in malleable iron annealing is supplied usually by an oxide packing material or by air, depending upon the type of annealing oven used.

For years it was thought that malleable iron annealing could not be accomplished unless the hard iron castings were packed in iron-oxide scale; but, as the tonnage of the industry rapidly increased, this packing material became harder to obtain, with the result that today most any kind of refractory material is used in the place of iron-oxide scale, and with comparatively good results. Some plants have even gone so far as to adopt the muffle-type oven, where no packing material is used. The castings are simply stacked in the oven and protected from contact with the flame by muffle chambers or by covering with sheet-iron plates and sand or scale. Practically the only difference in the results obtained is that more carbon is removed from the casting where a strong oxide packing material is used.

Regulating the Carbon

While decarbonization or the removal of carbon in the anneal is in most cases desirable, some, I am afraid, are disposed to overestimate its importance. In other words, it is the complete conversion rather than the removal of carbon in the anneal that determines the malleability of the product. It is a well-known fact that the higher the total carbon content in malleable cast iron (even though the conversion in the anneal be perfect), the lower will be its ultimate strength, the strength being affected in direct proportion to the minute cavities made necessary for graphite deposits in the ferrite structure. Even so, it does not necessarily follow that the removal of carbon in the anneal is absolutely essential to the production of high-grade malleable iron. While at least a small amount of carbon will always be removed in the anneal, the total carbon should be regulated in the white iron—a fact which cannot be too forcibly impressed upon those who desire to maintain a high-grade product.

While possibly somewhat foreign to my subject, the statement just made again emphasizes the importance of knowing the carbon content of the pig

iron entering into the mixture when charged into the melting furnace, inasmuch as the color method for making preliminary carbon tests, as used in steel practice, cannot be employed by the malleable melter, because the total carbon in hard iron is so much higher than in steel. Unless the total carbon can be regulated with some degree of accuracy and more than guesswork in the melting mixture, the hard iron will not be of such consistency that we can reasonably expect uniform results in the anneal, regardless of the type of oven or annealing practice employed. Therefore, I again call to the attention of the association a most valuable service which can be performed for its malleable members by setting into motion some plan for a united request or demand upon pig iron dealers to furnish and guarantee the total carbon analyses, as well as the various elements which it is their present practice to supply.

To further emphasize the importance of regulating the total carbon in the hard iron, I can state as an absolute fact that the best malleable cast iron never results from a hard iron composition in which the total carbon is around 3 per cent, regardless of the amount of carbon removed in the anneal. However, in this connection, caution should be used not to run the carbon too low, or trouble will result from other sources. If the total carbon is allowed to go below 0.20 per cent in the hard iron, the iron carbide will not dissolve under ordinary annealing temperatures, which is only one of the numerous troubles that will result from running the carbon too low.

Repeated Annealing Effect

In another part of this paper the statement is made that prolonged annealing will have no detrimental effect upon the physical strength of malleable cast iron, unless the temperature is run too high; also, that the removal of carbon in the anneal is not essential to the production of high-grade malleable iron. These statements are best corroborated by a series of practical tests conducted by Prof. Touceda, to whose liberal generosity I am indebted for many favors. In one of these tests eight test wedges were poured from the same ladle of iron and annealed in such manner that one of the wedges was annealed eight times, one seven times, and so on down the line until one of the wedges received only one anneal. Physical tests showed that there was practically no difference in ductility between the wedge annealed once and the one annealed eight times; and, after each successive anneal, the physical test showed but very little comparative variation in strength. Upon analytical examination, however, it was found that the total carbon was diminished by each successive anneal—the first anneal showing a total carbon of 1.40 per cent, while the eighth anneal showed that only 0.22 per cent of carbon remained. The test showed conclusively that the consistent removal of carbon in each successive anneal did not improve the quality of the product; and, at the same time, it demonstrated that prolonged or re-annealing, under normal conditions, will not affect the strength of the metal.

Muffle Oven Versus Pot Oven

There are two types of ovens generally used for annealing malleable cast iron; namely, the muffle oven and the pot oven, either of which has its particular advantages and disadvantages. The typical muffle oven is in reality an oven built within an oven, that is, the construction of the outside oven, or oven proper, is very similar to the pot oven, except that it encloses two small arches, separated by a partition, which form the muffle chambers in which the castings are placed for annealing. When filled with castings, the muffle chambers are sealed up as nearly air-tight as possible. The fire-box is arranged usually at the rear end of the oven in such manner that the flame passes directly over the arches of the muffle, returning through specially constructed flues in either side-wall and underneath the floor to the main stack flue at the back end of the oven directly underneath the fire-box. There is, of course, a damper in the base of the stack for regulating the distribution of heat throughout the oven, which is a simple matter if the flues are kept clean. The pot oven is nothing more nor less than the muffle oven, minus the muffle chambers.

Advantages and Disadvantages of Muffle Oven

The principal advantages in favor of the muffle type oven are the elimination of labor required to pack, handle and shake-out the pots, cost of packing material, expense of renewing pots, etc. Among the objections to the muffle oven may be noted the following:

1.—On account of the heat having to penetrate the brick arch forming the muffle chamber, it requires somewhat longer to bring the castings to annealing temperature.

2.—Not being supported by packing material, the castings are more apt to become warped or distorted.

3.—There is more danger of the castings becoming scaled, due to air leaking into the muffle.

4.—Small and delicately constructed castings cannot be annealed in this type of oven unless they are packed in trays.

The muffle type oven is particularly adapted to annealing medium and heavy castings, where packing material is not necessary to prevent warping and where a small amount of scale on the castings is not a serious objection. For this class of work the muffle type oven has everything in its favor.

The pot oven is used by some foundrymen probably because they have never tried any other method of annealing; by others, because the nature of their work requires that the castings be annealed in packing. There is no doubt but that the pot anneal produces a cleaner and better casting for machining or nickel-plating, but so far as physical strength is concerned, the pot oven has no particular advantage over the muffle oven. Of course, the principal objection to the pot oven is the expense and inconvenience of packing the castings in pots. However, where light and intricate castings are to be annealed, I can suggest no alternative.

Tests of Packing Material

For the purpose of further proving certain statements made in this paper, I had cast from the same ladle of iron a set of 30 test wedges and 30 tensile test bars. These were annealed in three lots of 10 wedges and 10 tensile bars each. Two lots of these tests were annealed in a pot oven, one lot being packed in mild packing material and one lot in strong packing material. The mild packing material was mill scale mixed with coke breeze; the

Comparative Results of Pot Oven and Muffle Oven Annealing

	POT OVEN		MUFFLE OVEN
	Mild packing, per cent	Strong packing, per cent	Without packing, per cent
Total carbon in hard iron	2.63	2.63	2.63
Combined carbon after anneal	0.53	0.13	0.05
Graphitic carbon after anneal	1.75	1.85	2.12
Total carbon after anneal	2.28	1.98	2.17
Total carbon removed in anneal	0.35	0.65	0.46
Wedge test, length of butt in inches	2⅞	2⅜	2
Tensile strength, pounds per square inch	49,448	50,044	49,542
Elastic limit, pounds per square inch	38,746	37,122	37,398
Elongation, per cent in 2 inches	6.3	6.7	7.3

strong packing material was iron-oxide scale. The third lot of tests was annealed in a muffle type oven, without packing material. The comparative results are shown in the accompanying table.

Total carbon in hard iron was determined from hard iron shot, cast in water. The carbon determinations after anneal were made from drillings taken entirely through the butt end of test wedges. The test wedge was 6 inches long, 1 inch wide, ½-inch thick at the butt, and tapered to a wedge point. The tensile test bars were round, ⅝-inch in diameter. Each of the tests represents the average for 10 bars, five of them having been annealed near the roof and five near the floor of the oven, about midway between front and back end.

Unfortunately, the heat from which the above tests were poured was too high in both carbon and manganese to produce an extremely ductile and tough material. However, it accomplished the purpose for which the tests were made.

By reference to the tabulated results, it will be noted that the mild packing material removed less carbon than the strong packing and that more combined carbon remained in the iron annealed in mild packing, which strengthens the statement previously made that in addition to removing more carbon the oxide packing material has a tendency to hasten the dissolution of the carbide after annealing temperature has been reached. I would also call attention to the fact that, while the muffle type oven removed less carbon than the oxide packing material in the pot oven did, the conversion of carbon in the muffle oven was more nearly complete. This, in conjunction with the results of the physical tests, proves that it is the conversion rather than the removal of carbon that produces the ductility.

Electric Arc Welding Applied to Cast Iron

By B W Bowers

WELDING cast iron by the electric arc has been characterized by many gray iron foundrymen and those concerned in machining such welds, as a problem of uncertain results due to the lack of knowledge of the nature of iron and the proper methods of procedure. Since cast iron fuses at a lower temperature than steel, the heat treatment, as applied in welding, is an important factor and must be borne in mind, if good results are to be obtained. There are two methods of welding cast iron with the electric arc, namely, by the metallic electrode and the carbon electrode. Each method has its limitations and work to be welded should be governed accordingly.

Metallic Method of Welding

By the metallic method, almost any defect or break can be repaired or remedied, providing the casting is clean and of good gray iron. A steel wire, from ⅛ to ¼ inch in diameter, generally is used as filling-in material by the metallic method. Some grades of cast iron are of such poor composition, that it is almost impossible to weld them by either process. The metallic method has played a prominent part in welding cast iron for marine and railroad service, especially where tensile strength is essential. It imparts so little heat that the strains, which are usually set up by electric welding, are not considered detrimental. While it must be admitted, that it is a slower process than the use of the carbon electrode, it has many advantages over that method. Work can be welded in position without dismantling, whether overhead, vertical or horizontal.

For iron foundries and machine shops the writer is of the opinion that the carbon electrode possesses advantages over the metallic process. However, in these plants the metallic electrode should be available, as there are numerous defects that can be welded to better advantage than with the carbon electrode. The writer intends to discuss the carbon method as applied to foundry work for repairing defects due to shrinkage, sand spots, broken corners or lugs and defects that appear during machining.

The range of work adapted to carbon welding is somewhat smaller than that

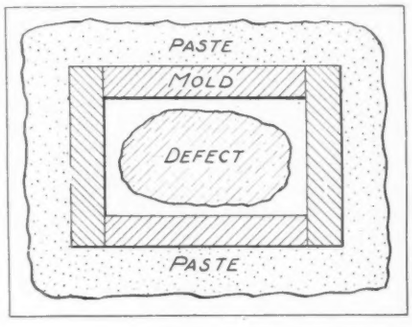


FIG. 1—PLAN VIEW OF MOLD SURROUNDING THE PART TO BE WELDED

of steel, due to the numerous difficulties effected by the sudden expansion and contraction of the metal in the welding area.

The most common faults with carbon welds on cast iron are hard spots due to the lack of adequate heat and proper filling-in material. Overheating expands the metal near the welding zone, resulting in small cracks. The majority of these difficulties can be eliminated easily, if the work is given careful consideration and by exercising the necessary skill and taking all possible precautions. The greatest drawback to welding cast iron with the carbon arc is that soft welds cannot always be assured on defects that are over 4 inches in area. To obtain a soft weld, the filling-in material must be kept in a liquid state until the weld is completed and should be covered immediately with hot sand to retain the heat. On defects larger than 4 inches in area, the flame of the arc cannot play over the entire surface at one time, which robs the weld of the proper degree of heat. Therefore, the metal is chilled and this results in hard spots. Defects larger than 4 inches should be welded by the metallic method, especially where tensile strength is an important factor. However, welds have been made on cast iron with the carbon arc, that showed a greater tensile strength than the original metal, but as such results could not always be repeated, it should be considered as possible, but not probable at all times.

Welding a Defective Casting

To follow the process carefully, it might be well to illustrate the welding of a defective casting. It will be assumed that a shrink hole is to be welded, 3 inches in diameter and about 1½ inches deep, the section of metal being about 3 inches thick. First, the defect must be cleaned out, removing all foreign substances, such as oil, grease or sand. This should be done with a pneumatic tool and should not be burnt out by the electric arc which would cause unnecessary strains and possible hard spots. The weld is actually cast by the arc and must be made in molds cut from graphite or other carbon material, enclosing the defect. Graphite is preferable to carbon having a lesser tendency to cause porous welds and is considerably cheaper than the other material. Burnt graphite crucibles can be used to advantage. The mold is made to conform to the outline of the defect and is cut about ⅛ or ¼ inch larger than the width and length of the section to be repaired. The mold should be from ½ to ¾ inch high and

is set over the defect as shown in Fig. 1.

All cracks and crevices must be closed with a paste made from two parts of pulverized carbon and one part of silicate of soda (liquid glass) to prevent the molten metal from spreading, during the progress of welding. This paste is spread around the outside of the mold and is pressed against both casting and mold, as shown in Fig. 2. When the heat strikes the paste, it hardens and holds the mold tightly in place.

Preheating the Casting

It is necessary to preheat cast iron prior to welding, in order to relieve the strains set up by the application of the arc. If the section to be welded is thin, a little warming is sufficient. Preheating the casting can be accomplished by a gasoline torch, allowing the defect to store enough heat to burn a pine stick. After preheating, the welding operation must be commenced immediately to avoid the loss of heat that has been stored in the casting. The filling-in material should consist of sticks, about ⅜-inch square, cut from coarse-grained charcoal pig iron, not recast. Sticks or rods that have been recast chill and are hard, resulting in blowy, unmachinable welds. The pig iron must be high in silicon which leaves the weld in a soft condition. The welding material should be low in manganese and sulphur, the following analysis giving excellent results:

	Per cent
Combined carbon	3.20
Manganese	0.26
Silicon	3.86*
Sulphur	0.018
Phosphorus	0.036

*As high as 12 per cent.

The filling-in material is used in the same manner as when welding a steel casting with a steel wire or rod.

When welding large defects the pig iron sticks may be broken into small pieces, approximately ¾-inch long. Several pieces are laid into the defect and melted, which may be repeated until the molten metal is near the surface, when feeding with the stick can be resumed. The metal must be kept in a liquid state throughout the welding operation and should not be allowed to cool as this produces hard spots. Therefore it is essential that the weld be completed without interruption. Sharp carbons for the electrode are recommended, to concentrate the flame at a narrow point, thereby eliminating an irregular and fluctuating arc. The current for a weld of this size should be about 400 amperes. Ordinarily, it should range from 350 to 500 amperes, according to the size of the defect. The filling-in material must be added until it rises to the top of the mold, providing a riser of ample size. Immediately after the weld is completed and while the metal is still liquid, it must be covered with fine, hot sand to a thickness of about 3 inches to retard cooling as much as possible.

Care must be exercised in preheating cast iron to relieve the strains properly. Small, light cylindrical castings, such as piston rings, should be warmed all over and the proper degree of heat should be applied at the part to be repaired. A cracked or broken spoke in a gear wheel must be warmed all over, since the rim usually is heavier than the spoke and has a tendency to crack further or at another place, if the strains set up by preheating are not considered. In this case it is advisable to start the preheating directly opposite the defect, so that the heat will gradually flow to the defect by radiation. Apply the heat to various parts of the wheel for a short time and the part to be repaired is heated last. Large defects, having a metal section more than 3 inches thick, should be preheated by a charcoal fire; a retaining wall of fire brick is built around the defect and is held in place by steel angles clamped to the casting. At least two bushels of charcoal should be spread over this area and a slow fire should be started. The fire should be given sufficient time to distribute its heat by radiation throughout the casting. After one hour or two the fire should be urged until the metal around the defect is hot enough to burn a pine stick. This is a temperature of about 700 or 800 degrees Fahr. Then the charcoal can be removed and welding should be started immediately.

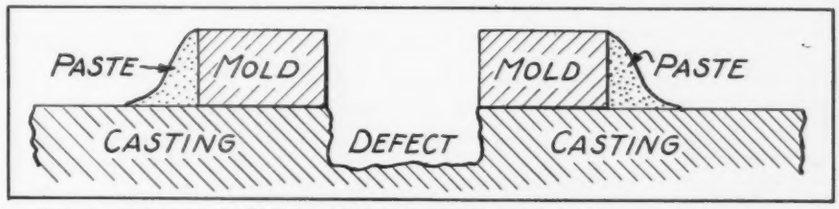


FIG. 2—CROSS-SECTION OF MOLD EXTENDING ABOVE THE DEFECT TO FORM A RISER OVER PART TO BE REPAIRED

Lugs or bosses may be readily welded to iron castings with entirely new metal. The mold is cut out to fit the lug or boss pattern snugly and is blocked or clamped in position. The welding metal is melted the same as for any other defect.

Welding Cracks

Cracks in cast iron are not easily welded as they usually extend further when the heat is first applied. Frequently a ¼-inch hole is drilled at the beginning of the crack and extending beyond its depth to check further rupture when the heat is first applied. The crack then is cut out to a v-shaped slot by a pneumatic tool. This method can be applied to cracks not over 4 inches long. Larger cracks should be chipped out and welded with the metallic electrode, which applies a lower degree of heat.

Fluxes are not absolutely necessary, but can be used at the operator's discretion. The majority of prepared fluxes contain an abundance of iron oxide which produces a sticky slag and simply adds to the operator's troubles to eliminate it.

Small blow-holes frequently develop in cast iron welding and a small amount of sodium chloride (common salt) added while welding, will eliminate the gases which seem to be the cause for this sponginess.

In welding cast iron the following suggestions should be observed:

1.—Defects should be cleaned or cut out with pneumatic tools and not burnt out by the electric arc.

2.—Molds enclosing the defects must be tight, allowing no molten metal to escape. They must be cut higher than the surface of the casting to allow a good-sized riser which aids in retaining the heat adjacent to and at the weld, insuring soft metal in the weld. Slag and other impurities rise into this head which is cut off after the weld is cold.

3.—Preheating must be applied in the proper area to relieve the strains and should not exceed 700 or 800 degrees Fahr.

4.—Proper preheating, the right welding heat and heat retention are important.

5.—Sharp carbons for the electrode are essential in eliminating a fluctuating arc.

6.—Current supply should not be less than 350 amperes and not more than 500 amperes, according to the size of the defect.

7.—Filling-in material must be cut from charcoal pig iron (large grained) in the raw state. It must not be recast into strip form. It must be high in silicon and low in manganese and sulphur.

8.—Welding must begin immediately after pre-heating and must be completed without stopping.

9.—A little sodium chloride (salt) added occasionally, will eliminate small blow-holes.

10.—Immediately after weld is completed and while the metal is still liquid, cover with fine, hot sand and let it remain covered until it is entirely cold.

Efficient Pattern Shop Methods That Save Time

A Novel Method for Producing a Hopper Pattern is Described and Cheaply-Made Gear and Pulley Models Are Discussed

By J H Gard

WHEN labor is plentiful and materials cheap, pattern shop economies frequently are overlooked. Many foundry superintendents hesitate to dig into the details of pattern shop practice, and usually are satisfied if good patterns are produced at a reasonable labor cost. At the present time, however, with labor at a premium and prices of materials advancing steadily, it is evident that a few hours saved here and there in the pattern shop are worthy of more than ordinary consideration. One method of saving such time and material is through the use of skeleton patterns. For comparatively large castings, these patterns often save many hours of labor on the part of the patternmaker, inasmuch as the time spent in making a skeleton pattern is insignificant when compared with that consumed in making a solid pattern in the regular way. A specific example will illustrate this point.

Fig. 1 shows a hopper casting, 6½ feet in diameter and 32 inches deep. The metal section is one inch throughout. The pattern for this casting necessarily takes the shape of a truncated cone with a base 6½ feet in diameter and an altitude of 32 inches.

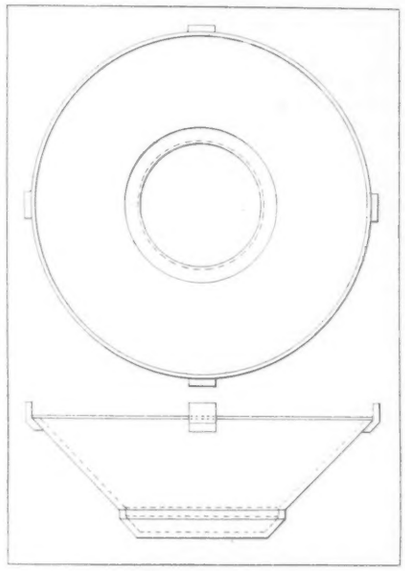


FIG. 1—A HOPPER CASTING MADE FROM A SKELETON PATTERN

A suitable solid pattern could be made only by gluing together successive rings of diminishing size and turning the whole in a lathe to the proper contour, or by some similar piece-by-piece method. The skeleton pattern actually used on the job was extremely simple and at the same time entirely satisfactory. It consisted of two rings, one forming the lower and the other the upper base of the truncated cone, properly held together by light wooden struts corresponding to meridians on the conical surface.

In making a pattern of this kind, the first step is to turn the ring that forms the upper base of the cone. This ring, which is shown on the floor in Fig. 2 is built-up, glued and turned in the regular way. The larger ring that forms the base of the pattern also is shown in Fig. 2. It is built-up in four thicknesses. The foundation course is first screwed and glued to the face-plate of the lathe, after which the other courses are built on. The ring is then turned on the outside and inside with the exception of the first course at the back.

The next step is to fit in place the 12 struts which form the skeleton outline of the pattern. They are

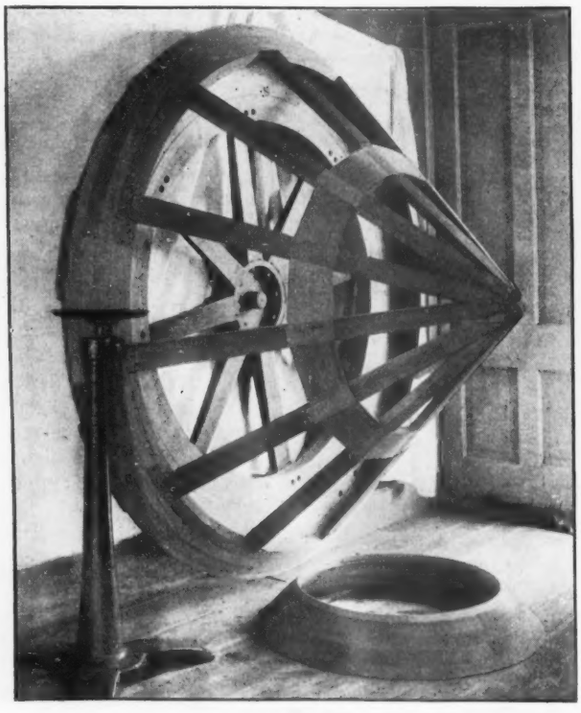
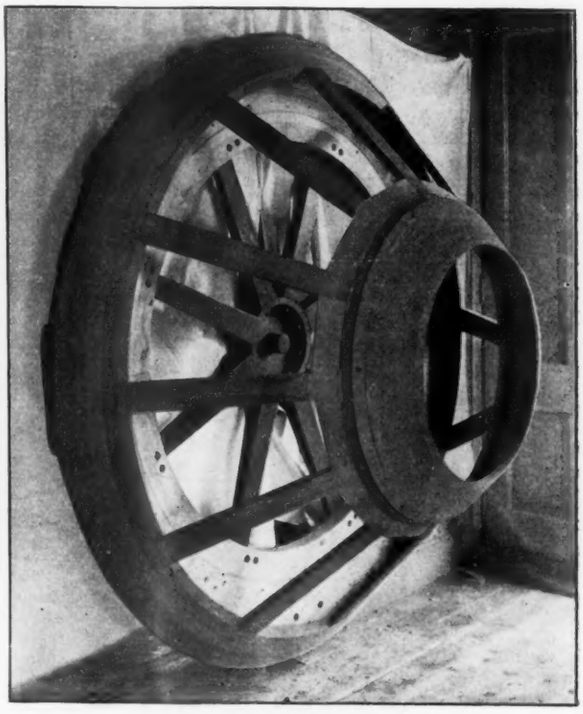


FIG. 2—THE HOPPER PATTERN IN PROCESS OF CONSTRUCTION



THE HOPPER PATTERN FINISHED AND READY FOR USE

assembled at the top and securely screwed together, forming a complete cone, as shown in Fig. 2. Small chocks are next built-in between the struts at the point where the smaller ring is to be fitted. These are securely glued and nailed in place. After the glue has set thoroughly, the chocks are turned to align with the large ring. More chocks are then glued and nailed in place over the first course. This construction ties the struts securely in place. The upper ends of the 12 struts next are sawed off and the ring formed by the small chocks is turned on the outside and inside. Also a seat is turned to accommodate the small ring shown on the floor. This ring is fastened in place with glue and its outside diameter is turned to make it align with the rest of the pattern. The pattern is next sandpapered thoroughly and removed from the face plate. The chucking piece is now cut away which leaves the pattern in the form shown in Fig. 3.

By this method a great deal of time is saved, for otherwise the entire pattern would have to be built-up of small pieces laid in courses and glued. The design of the skeleton pattern is such that the molder can ram both sides without rolling the job over. A straight sweep is used to remove sufficient sand between the struts to allow for the necessary thickness of metal.

A Simple Wheel Pattern

Patterns for gears, pulleys and flywheels are comparatively expensive owing to the amount of hand labor involved. Excellent results, however, may be obtained by using a simple method whereby the pattern is built-up in segments and turned to the desired size. A pulley pattern made by this method is shown in Fig. 4. In making the pattern, the arms are first sawed roughly to shape and left a little longer than the radius desired. The inner ends are then sawed to the required angle to make the joint at the center. The included angle for eight arms is 45 degrees; for six arms, 60 degrees; for five arms, 72 degrees and for four arms, 90 degrees.

Notches are next cut at the inner ends of the arms, as shown in Fig. 4. Their purpose is to fasten the arms securely together by means of tongues. The arms are built-up in pairs. Two saw cuts are made on each side of each arm in the first pair at the point where the tongues are inserted. The tongues are then glued in place and the joint between the two arms glued and clamped tightly. After the glue has set thoroughly another arm is added to the first pair and so on until all the arms are glued in place.

The next step is to build-in the segments that are to form the center course of the periphery or rim of the wheel. These segments and the arms are fitted together by means of tapered joints, illustrated in Fig. 4. The joints can be tongued if desired, but as a rule, a glued and nailed joint gives entire satisfaction, and is much more easily constructed.

The pattern is then mounted on the face-plate of the lathe, the segments are turned off to the proper diameter and one side is finished. The pattern is next reversed and the other side turned. Then the pattern is taken to the bench where the arms are finished by hand planing.

At each filleted corner the arms and inner surfaces of the segments are rounded over to the center with a gouge working from each side. This leaves a starting point for the chisel. With the beveled side of the chisel toward the work, the patternmaker works away from the corners into the straight parts of the arms and the plain curves of the segments. Next, with the flat side of the chisel he works to each of the corners. If any irregularities are left they are removed with a spoke shave. The work is next sandpapered carefully. The pulley pattern shown in Fig. 4 is for a 36-inch wheel and the arms were finished in the manner just described in three hours.

The next step is to build courses of segments on each side of the center segment to form the face of the pulley to the desired width. In placing the segments in position the joints should be staggered and the first row on each side of the center course should overlap the arms.

The pattern is then remounted in the lathe to turn the rim. If possible, the pattern should be chucked on a comparatively small face-plate so that both sides of the rim can be turned at one setting. This not only saves an extra setting, but insures a perfectly true wheel.

The hole in the center of the arms can be from 1 to 2 inches in diameter, the object, of course, being to accommodate hubs of different sizes. The hubs are turned with a pin to fit the hole in the pattern. This assures hubs that are centrally located as well as readily interchangeable.

Gear patterns may be made by the same method. If the teeth are to be cast, the periphery should be turned carefully to the desired diameter, but not sandpapered. This leaves a better holding surface for the glue. The teeth are made up to the desired form and are carefully glued and nailed in place. They can be nailed through the teeth or through the rim as the patternmaker desires.

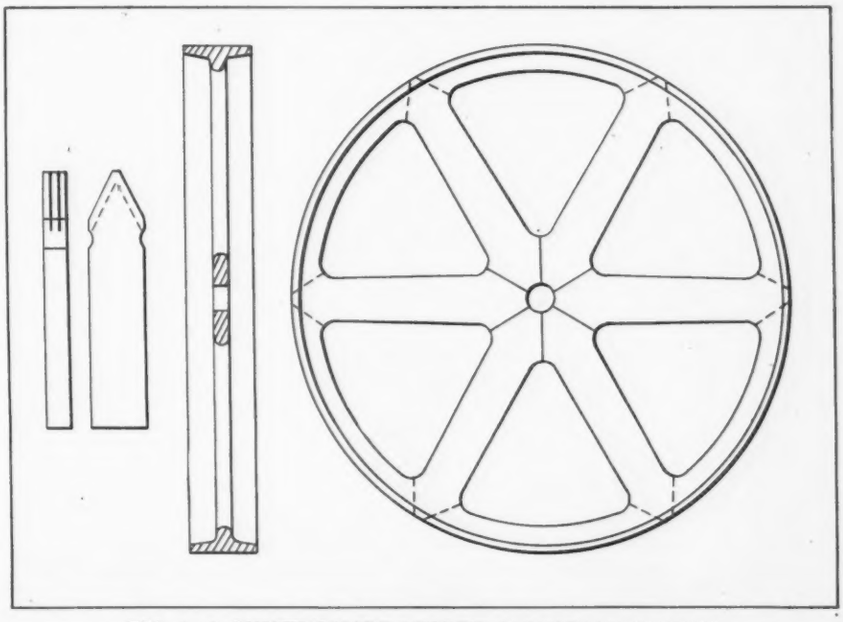


FIG. 4—A QUICKLY-MADE PULLEY AND GEAR PATTERN

Will Purchase Equipment for Export

Leon Belge, representing Philippe Berger, No. 2 Square De L'Opera, Paris, France, machinery exporters and importers, will be at the Hotel Biltmore, New York, during the months of April and May for the purpose of purchasing machinery and equipment for delivery abroad. He also will entertain propositions from manufacturers desiring to introduce their equipment into France and other European countries.

Results of Use of Permanent Molds in England

Trench Mortar Bombs Were Made by This Method for the Ministry of Munitions, But This Has Been Discontinued and These Castings Are Now Made in Sand

HEAVY trench mortar bombs have been cast successfully in permanent molds in England and the process was the subject of an address, recently delivered before the Birmingham (Eng.) branch of the British Foundrymen's association, by M. Riddell, Glasgow, president of the Scottish branch of this organization. Mr. Riddell stated that when inquiry was made for the production of these gray iron castings, samples were exhibited and analyses were furnished. It was apparent from the analysis specified that sand castings would not meet the requirements and, therefore, the permanent mold was resorted to. Mr. Riddell stated that he counselled other foundrymen to ignore the chemical analysis and to consider the problem one of meeting the physical requirements solely. It was necessary to consider to what extent these principles could be controlled to attain the desired end, and for that purpose it was decided to experiment with iron molds. As it developed subsequently, the use of permanent molds was stipulated, and it was not long until several foundrymen were confronted with difficulties, in spite of the fact that an analysis of a suitable iron was furnished as a guide. The speaker stated that he experienced considerable difficulty, in spite of the prominence given to the analysis and to recommendations from a source which claimed to have had much experience with permanent molds, that it was necessary to use an iron containing not more than a certain quantity of combined carbon. It seemed rather strange that of all the substances which go to make up cast iron, the combined carbon should be given such prominence as a determining factor, considering that the percentage of that constituent varies in different pigs from the same cast and at different ends of the same pig according to the rate of cooling and that it completely disappears as a distinct component in the molten metal, and that the percentage in the pig can give no indication of how much will appear in the casting. Except for the information it may give as to the melting qualities of the pig iron, Mr. Riddell stated that it would be much better if combined carbon were excluded from analyses of mixtures altogether.

Even in the examination made to ascertain the physical condition of a casting, a knowledge of the amount of combined carbon will give very little information and it even may be misleading, unless at the same time the examiner knows in what particular form it is combined, whether in solid solution or as free carbide, and also how distributed in the casting. This last stipulation is particularly applicable to castings made in iron molds, because it is frequently found that while the analyses reveal a very low percentage of combined carbon that carbon is concentrated in a very thin skin with a high percentage of carbon and which renders the casting unmachinable.

Pouring Metal Into Permanent Molds

The pouring of molten metal into an iron mold naturally has the effect of hastening the rate of solidification. The fine grain generally found in castings so made, is due to this effect and not, as has been asserted, to liquid pressure on the mold during freezing. If such pressure was exerted while the metal was liquid, or even plastic, it would adjust itself according to natural laws. The best evidence that pressure is not responsible for the fine grain will be obtained from an examination of a sand casting where the inside which is freezing under pressure from the solid, and contracting outside, has a coarser grain than the outside that solidified under practically no such pressure. It is also noteworthy, in this connection, to point out that the larger the section of the casting, the coarser is the inside grain, notwithstanding the greater pressure exerted. The theory of the writer is that the actual size of the grain is determined by the initial temperature of the molten metal and the rate of freezing. There is some relationship between the size of what might be called liquid grains and the temperature. At the vapor point these liquid grains are of infinitesimal proportions, but as the temperature falls they gradually absorb and assimilate each other. The absorption takes time and the extent to which it is carried will depend on the rate of cooling. Quick cooling from a high temperature produces fine grain, while with very slow cooling is obtained a large-sized and coarser grain in the casting. The condition of the grains found in meteorites is a good illustration of the operation of this law.

Cooling Effect of Permanent Mold

The cooling effect of the iron mold continues after the metal becomes solid, and it is here that the complications and difficulties are introduced. Unless the casting is of a somewhat heavy section, it may be cooled, either in whole or in part, too rapidly to permit of the changes which are necessary before all the carbon can separate out from the solid solution. When this happens it will be found that the parts of the casting so affected are excessively hard or chilled, and that it will be most difficult, and in some cases impossible to remove the chill or hardness by ordinary process of softening cast iron.

To insure that a casting shall have its maximum softness, it is essential that cooling to below the pearlitic change point should be as prolonged as possible. The problem presented, therefore, by the iron mold consists in devising means for counteracting the rapid abstraction of heat from the casting, and retarding the rate of cooling through the critical range. To accomplish the first result, the molds must be so constructed that the castings can be removed from them as soon as they are set. For retarding the cooling of the castings, a number of pots lined with fireclay and heated previously to the cast were located near the permanent molds. The castings were immediately transferred to the pots, buried in a mixture of sawdust and floor sand, and allowed to cool. By this method the castings were able to retain some heat at the end of from 36 to 48 hours. Any casting which had cooled to a dull red before it could be put into a pot was thrown aside as a waster.

That the method was effective was proved by analyses made at various times showing mere traces of combined carbon and also by reports received from the machine tests.

The most serious difficulty to be overcome in the use of iron molds is the elimination of air holes and hard spots. One, and probably the most prolific, cause of air holes in castings arises from a source which is not generally recognized by foundrymen, at least it is never mentioned in discussions on that subject, namely the action of the metal while being poured. If one observes what happens when a stream of water from a tap falls into a basin containing water, he will notice that a considerable amount of air bubbles is produced, and also that they are carried well below the surface of the water. The same action will take place when iron is being poured into the gate of a mold. To meet this in the case of a nonporous permanent mold an air trap between the gate and the casting has to be introduced. It is essential to make the trap of ample dimensions because the rapid cooling effect of the mold quickly forms a skin of rather

viscous metal through which the air cannot escape. The entrapped air will be carried in the upper portion of the runner and the capacity of the trap must be sufficient to insure that it can take the aerified portion of the incoming metal. As an extra precaution in this direction the runner to the casting has a step down from the trap and is at a lower level than the entry to the trap.

The microscope shows that the hard spots are composed of what Dr. Stead calls the ternary eutectic of iron carbon and phosphorus, which has extruded into a convenient air hole. The film of oxide which is to be seen around the hard spot shows that there is a close relationship between it and the air holes. At any rate, when the air holes were eliminated, the hard spots likewise disappeared.

Permanent Mold Described

In describing the permanent mold, Mr. Riddell said that the basin at the bottom of the gate is for the purpose of preventing the mold from burning away through the pouring of the metal. The metal that first enters the basin quickly loses heat and forms a cushion for the metal which is being poured in and thus prevents the bottom of the mold from being in contact with fresh metal from the ladle. Molds so constructed have been in daily use for months without signs of serious wear in this part.

A riser should always be used when the forms of the castings permit it. The first metal which enters the mold has its temperature quickly reduced and if allowed to enter the casting is liable to create a chilled spot. The riser serves to divert this cooled metal past the casting.

As the speaker did not believe that liquid pressure can have much effect on the molds he considered it advisable to have the parts held together, either by wedges or by some other equally rigid method. The tables or stools on which the molds with the wedges are placed have occasionally been broken, through the forcible driving of the wedge when closing up, but in no instance has one been known to give way under pressure exerted by the solidifying metal. It is not necessary to machine the faces of the mold so long as they have been carefully made and fit together close enough to prevent the metal from getting into the joints. Mr. Riddell said that there is some divergence of opinion as to the best iron to be used in making permanent molds, but so far as cast iron work is concerned, there is really no need for selecting any special mixture.

Distortion of the molds resulting in the opening up of the joints has been another source of trouble in some foundries. It is worth while pointing out that the distortion takes place when the molds are out of use and not during the casting operations, and particularly when a rigid form of closing is adopted. When the cast is finished the inside part of the mold is generally at a red heat while the outside is comparatively cold. Consequently, there is a difference in the amount of contraction between the inside and outside when cooling, and if allowed free scope, will pull the mold out of shape. To prevent this the mold should be closed and the wedges driven into place immediately after the cast is finished. One firm, whose molds had been left open and become distorted was able to bring them back to condition by running metal into them until heated and then wedging them together as suggested.

The foregoing will indicate the principal difficulties which are encountered in working with iron molds. In the operation of the molds and considering that speed of handling is of such vital importance, it was necessary to organize squads of men, each with his own particular duty, for each set of molds. Each man pouring metal has five or six attendants, according to the size of the mold, in order that the operations may be carried through with a feeling of assurance in the results. These arrangements naturally make the process more costly than sand molding, and its only merit will lie in the superiority of the castings for a specified purpose.

Permanent Molds Save Cost

For castings which are not machined and in which hard spots and patches may lie undiscovered, there is no doubt that permanent molds can be used more extensively than at present. In this case the mold is always ready for use and the cost of casting will be less then in sand work.

That the use of permanent molds for the manufacture of bonds, grenades, etc., has been abandoned by the ministry of munitions was indicated by the following letter received by Mr. Riddell from Arthur A. Rowse, chief engineer:

"This department used chill molds for the production of a certain type of heavy trench mortar bomb. The idea was that the chilled exterior would render the iron impervious to the propellant gases. It was found that the molds were expensive to make and had a comparatively short life for accurate work, less than 1000 bombs. It was further found that a casting made in sand and tested to 1000 pounds water pressure was equally satisfactory. The chill mold system, therefore was abandoned. No articles are at present being made for this department by the chill method, though various experimental castings of grenades, etc., have been made. Broadly speaking, manufacturers in this area have very little experience in the process, and the ease with which the articles we demand are made in sand offers no inducement for a change."

Champlain Metals Corp. Organized

The Champlain Metals Corp., 165 Broadway, New York, has been organized to deal in steel, ferroalloys and chemicals for both the export and domestic trade. It represents exclusively several large eastern steel mills and two large eastern chemical plants. The officers of this company follow: President, Clements Batcheller, formerly connected with the Carnegie Steel Co. and the Tennessee Coal, Iron & Railroad Co. as sales representative; vice president, Ellis O. Friedman, president of E. O. Friedman, Inc., Albany, N. Y., dealer in iron and steel; treasurer, Leonard Kennedy, vice president, Ludlum Steel Co. and formerly affiliated with William A. Reed & Co., bankers; secretary, Hiland G. Batcheller, vice president, Ludlum Steel Co.

The sales department is in charge of Wilson W. Gephart, formerly with the operating department of the Illinois Steel Co., Gary, Ind., and R. G. Williams, formerly affiliated with the sales department of the Central Tube Co. In addition to the officers the board of directors consists of Parker Corning, vice president and treasurer, Ludlum Steel Co. and a director in several banks, and Edward Corning, president, Ludlum Steel Co., treasurer Albany Felt Co. and director of the Albany Savings bank.

Another McLain-Carter Furnace Installed

The Lucey Mfg. Corp., Houston, Tex., made the first heat in its 5-ton McLain-Carter oil-fired open-hearth furnace, aturday, March 9. The metal was poured into castings and billets. One billet was removed from the mold immediately after casting and it was pierced and drawn out on a steam hammer to form a long liner. The furnace was installed by the McLain-Carter Furnace Co., Goldsmith building, Milwaukee.

Carborundum is carbide of silicon, which is made by heating silica with coke in a roughly constructed electric furnace in the proportion of 60 parts by weight of sand to 36 parts of carbon. By modifying the proportion of sand, graphite can be made in the same furnace.

The New York office of White & Bro., Philadelphia smelters and refiners, has been removed to 821 Trinity building. C. G. Dickinson is in charge.

The Practice of Melting and Casting Aluminum--II

In This Article the Metallography of Cast Aluminum is Discussed and Several of These White Metal Alloys Also Are Considered

By Robert J Anderson

IN the preceding article on this subject, a survey of aluminum melting and casting methods was presented. This article takes up briefly the metallography of cast aluminum. A few of the common casting alloys of aluminum also are treated. Aluminum has not been subject to extensive metallographic investigation. Nevertheless the microscope is a valuable apparatus for examining the internal structure of both aluminum and its alloys, and furnishes reliable information which cannot be obtained by any other method. Aluminum is usually received in the form of pigs which weigh about 33 pounds; these pigs have been cast in chill molds and the metal has frozen rapidly. Fig. 1 shows a photomicrograph of cast pig aluminum which has a dendritic structure resulting from fast chilling; this photomicrograph was taken at a point contiguous to the iron of the chill mold.

Fig. 2 was made from a photomicrograph showing the appearance of the metal in the interior of the pig; it illustrates the crystalline allotriomorphic grains with the impurities segregated to the boundaries. Fig. 3 illustrates the appearance of sand-cast pure aluminum. The microsection from which the photomicrograph was taken was secured from the riser of a casting. In Fig. 4, there is shown the dendritic structure of chill-cast pure aluminum; in this case, the microsection was cut from a chill-cast unruptured tensile test bar. The same specimen at double the magnification is shown in Fig. 5.

A large number of binary and ternary alloys of aluminum have been studied, but the most important alloys from the commercial standpoint are those with copper, manganese and zinc. Aluminum-magnesium alloys have also come into prominence in late years under the terms magnalium and duralumin. Aluminum-nickel is a valuable alloy whose possibilities are apparently not fully realized. Certain of the ternary alloys such as aluminum-copper-manganese are important commercially, while an alloy containing aluminum, copper and nickel has remarkable properties—conferred upon it mainly by the nickel. The casting procedure for these various alloys is essentially similar to that for pure aluminum.

Table I
Production of a 25-75 Per Cent Manganese-Aluminum Alloy

Charge

	Pounds
Aluminum	136
Manganese	50
Total metal	186
Alloy poured	168
Loss, through oxidation, dross, etc.	18

Alloy poured analyzed 22.71 per cent manganese.

Analysis of Manganese Metal Used for Melting

	Per cent
Silicon	2.73
Iron	2.27
Aluminum	1.09
Chromium	0.44
Manganese	92.00

Analysis on 1.5 Per Cent Manganese-Aluminum Alloy Made From Foregoing: 22.71 Per Cent Manganese-Aluminum Alloy

	Per cent
Silicon	0.44
Iron	0.45
Copper	0.12
Manganese	1.65
Aluminum	97.34

The alloys of copper and aluminum usually used are those containing 4 per cent and 8 per cent copper respectively, the remainder being aluminum with normal impurities. Aluminum-rich alloys containing copper in varying amounts have been studied by Carpenter and Edwards. With the introduction of copper into copper-aluminum alloys up to 8 per cent, there is a marked increase in the yield point, but not such an increase in ultimate strength as might be expected. The ductility is reduced by the addition of copper up to 3 per cent. These remarks refer to sand-cast aluminum-copper alloys. It is readily seen that 8 per cent copper alloys with aluminum are more brittle than those containing say 4 per cent copper. As a rule, chill castings of these alloys are better in tensile strength and ductility than sand castings of similar composition, so that alloys with up to 4 per cent copper have fair ductility, but those with 8 per cent copper have little if any. These remarks are elaborated by the figures in Table II, which show the results of physical tests on alloys made by the writer.

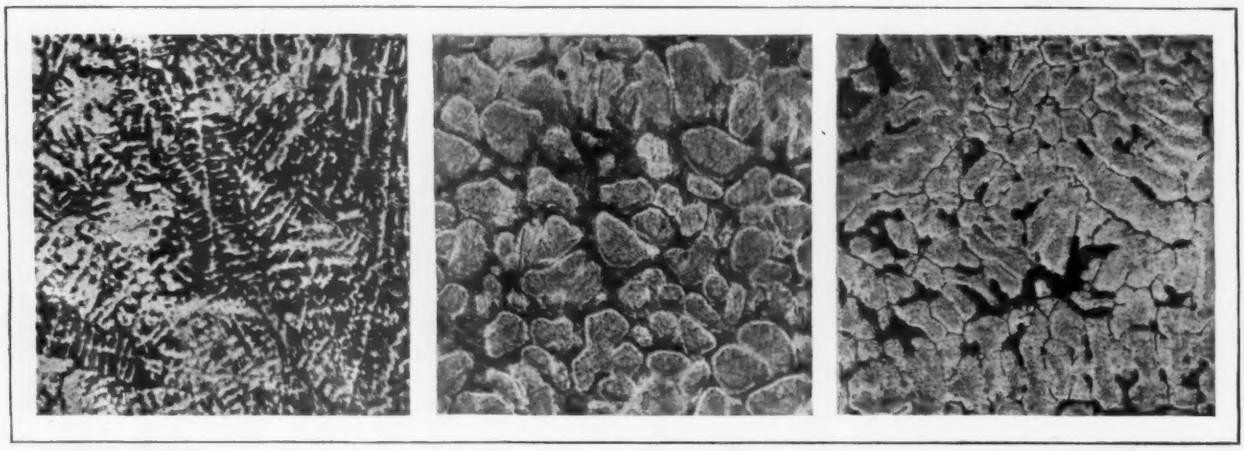


FIG. 1—CAST PIG ALUMINUM; CHILL CAST; ETCHED WITH HYDROFLUORIC ACID; 40 DIAMETERS FIG. 2—CAST PIG ALUMINUM; PHOTOMICROGRAPH TAKEN IN CENTER OF PIG; ETCHED WITH HYDROFLUORIC ACID; 100 DIAMETERS FIG. 3—SAND CAST ALUMINUM; ETCHED WITH HYDROFLUORIC ACID; 50 DIAMETERS

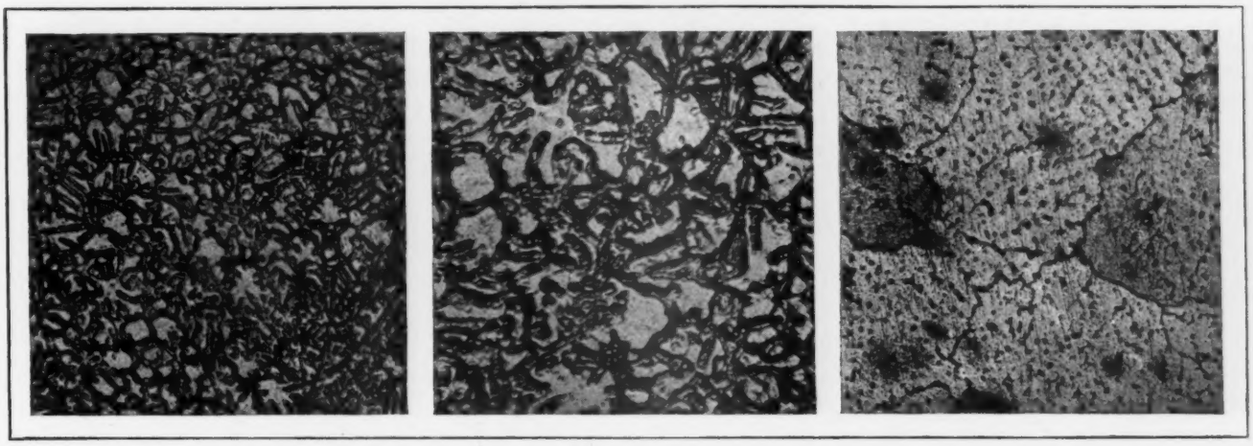


FIG. 4—CHILL-CAST ALUMINUM; ETCHED WITH HYDROFLUORIC ACID; 50 DIAMETERS FIG. 5—CHILL-CAST ALUMINUM; ETCHED WITH HYDROFLUORIC ACID; 100 DIAMETERS FIG. 6—PHOTOMICROGRAPH OF DEFECTIVE CASTING CONTAINING 4.90 PER CENT COPPER; ETCHED WITH HYDROFLUORIC ACID; 50 DIAMETERS

For certain more intricate castings which might have to withstand some stress, an 8 per cent copper alloy would be too brittle, whereas pure aluminum would shrink too much to faithfully reproduce the pattern. A low-percentage manganese-aluminum alloy would also shrink too much, so that a 4 per cent copper alloy might be satisfactory. When melting copper-aluminum alloys for casting purposes, the two component metals may be melted separately, and the correct mix then made, or the aluminum may be melted and superheated, and the copper then added with continued heating until it has all gone into solution.

The effect of high pouring temperature on an aluminum-copper alloy containing 4.90 per cent copper is illustrated in Fig. 6, which is a photomicrograph of a section cut from a defective casting which failed in service. At 50 diameters, the grain size is obviously very large, and while no grain size count is at hand, it is self-evident that the pouring temperature was altogether too high. The metal illustrated consists of a solid solution of copper in aluminum with a small amount of eutectic segregated to the boundaries. The latter is seen only under much higher magnification.

Table II

Physical Properties of Sand and Chill-Cast Copper-Aluminum Alloys

Alloy number	Copper, per cent	Elastic limit, pounds per sq. in.	Ultimate strength, pounds per sq. in.	Elongation on a 4-inch length, per cent	Reduction of area, per cent	Hardness sclero-scope
161	4.25	6,840	15,900	3.25	5.2	4
162	8.50	8,860	18,000	1.25	...	13
163	4.25	7,375	24,300	7.00	8.1	..
164	8.50	10,300	27,200	2.00	3.8	..

Nos. 161 and 162 were cast in sand; the pouring temperature was 690 degrees Cent.
Nos. 163 and 164 were cast in an iron chill mold; the pouring temperature was 730 degrees Cent.
No. 162 was a poor test bar.

The commonly used alloy of aluminum with manganese is one containing 1.5 per cent manganese. This is a difficult alloy to produce, mainly because of the wide difference in the melting points of the two metals, aluminum melting at 657 degrees Cent. and manganese at 1260 degrees. The usual procedure is to melt aluminum and to add thereto a 25-75 per cent manganese-aluminum alloy such as may be obtained in the market, or else such an alloy may be made by melting aluminum and manganese together. If the additive alloy is made, it is better to use pea size elemental manganese rather than dust or hickory or walnut sizes, since the former causes dusting losses due to blowing out of the pot, while the latter take longer to melt because of the relative massiveness compared to pea size. Whatever the source of the manganese, this is incorporated into the aluminum by simple melting. For making a large heat of 1.5 per cent manganese-aluminum, it is advisable first to charge into the melting furnace approximately enough of a 25-75 per cent manganese-aluminum alloy to produce a final alloy containing 1.5 per cent manganese, as may be readily found by simple calculation. Then pig or scrap aluminum should be added from time to time until the whole

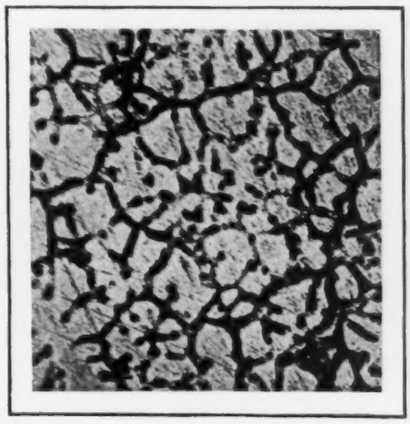


FIG. 7—PHOTOMICROGRAPH OF CHILL-CAST MANGANESE - ALUMINUM ALLOY CONTAINING 1.65 PER CENT MANGANESE; ETCHED WITH HYDROFLUORIC ACID; 100 DIAMETERS

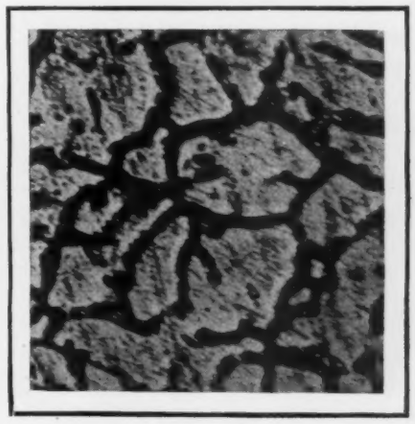


FIG. 8—PHOTOMICROGRAPH OF CHILL-CAST MANGANESE-ALUMINUM ALLOY CONTAINING THE SAME PER CENT OF MANGANESE AS IN FIG. 7; MAGNIFIED 150 DIAMETERS

charge is in, when the molten metal should be stirred and churned in order to insure the thorough distribution of the manganese. Considerable dross is produced in making this alloy. Samples of the melt should be secured before casting, and sent to the laboratory, where the manganese content can be obtained in 20 minutes. If the bath runs too low in manganese, more of the 25-75 per cent alloy can be charged to raise it, while if too high, aluminum can be added. It is better to aim for a higher manganese content than desired, and reduce it by additions of aluminum, rather than to have the manganese too low, because of the difficulty of incorporating manganese.

A 25-75 per cent manganese-aluminum alloy can be made by first melting the manganese, and then adding aluminum, until the melt is complete. The metal should be thoroughly stirred and then poured into small pigs which are used as the source of manganese in casting manganese-aluminum alloys of various manganese contents. Chemical analysis of the resultant pigs will give the percentage of contained manganese which is necessary for the calculation of charges. Data on the production of such an alloy are given in Table I.

Fig. 7 is a photomicrograph of a 1.65 per cent manganese-aluminum alloy, taken from a microsection of a chill casting, while Fig. 8 is the same metal at a higher magnification.

An erroneous notion has prevailed that manganese and aluminum form a series of solid solutions, but the facts in the case are that additions of even small amounts of manganese to aluminum produce alloys which are hard and brittle. This, of course, is contrary to the theory of solid solutions. The manganese alloy containing 1.5 per cent manganese has a higher ultimate strength than pure aluminum.

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

Preventing Oxidation in Naval Brass

In casting naval brass we are having high losses, since the metal on the cope side appears to contain a large quantity of slag. The alloy that we are using consists of copper, 62 per cent; zinc, 37 per cent and tin, 1 per cent. The copper is melted under glass and when fluid the zinc and tin are added. We pour fairly hot and the gates and risers are larger than we use in gray iron castings.

The reason why naval brass causes so much trouble is due to the fact that the zinc content is too high for a good sand casting metal. The remedy is to add aluminum, but the amount must be maintained at the minimum. We suggest that you make an alloy containing 90 per cent copper and 10 per cent aluminum, which should be poured into thin strips or into water to granulate it. Add 0.05 per cent of this aluminum bronze to the naval brass, which will add only 0.05 per cent of aluminum. This should greatly improve the casting quality of the mixture. However, if no improvement is noted, slightly increase the addition of aluminum bronze, but this should be done carefully. The specifications of the navy department covering naval brass do not prohibit the use of aluminum and no castings made from it, with the possible exception of valves, would be injured by its addition. Furthermore, if the aluminum content is kept at the minimum, it is doubtful whether leakage would occur when cast into valves, and this is practically the only form of casting affected.

If the specifications prohibit the addition of aluminum and the mixture must be used as specified, when pouring the castings it will be necessary to keep the heads full to prevent air from being drawn into the mold with this falling stream of brass. The air oxidizes the zinc and the resultant zinc oxide forms dross in the cope side of the casting because the zinc oxide is very light and floats on the metal. If the formation of zinc oxide is prevented, clean castings may be produced. When aluminum is employed, it forms a tenacious film of oxide over the metal and prevents the oxygen of the atmosphere from attacking the zinc and forming a zinc oxide.

One of the early methods of casting yellow brass involved gating the casting, so that the head could be kept full of metal throughout the pouring period. The metal was poured strongly and the molds were well vented. In the case of smaller castings, the metal was rushed into the molds and it was always considered better practice to overflow the heads onto the floor than to permit the metal to draw down before the head was entirely filled.

On heavy yellow brass castings, skim gates should be used and a feature to be aimed at in pouring is to keep pressure on the mold and never to allow the air to be drawn down the sprue with the metal and to rush out of the risers. Heavy yellow brass must be poured quite cool as otherwise it will be cut and scab the molds. If these precautions are observed, yellow brass, high in zinc, may be cast without aluminum. However, when the aluminum can be employed and used properly, it constitutes a valuable flux in connection with the casting of yellow brass.

Shrinkage of Solid Brass Bushings

We have been attempting to make solid brass bushings varying in size from 2 to 4 inches in diameter. Shrinkage occurs near the upper ends of the castings and these hollow formations, in some instances are so deep that the castings appear almost broken in two. Our mixture consists of heavy red brass scrap and 20 per cent of copper. The castings were gated on the bottom and were provided with risers. Numerous experiments were tried in differently locating the riser, but the results were not sasisfactory, as the shrinkage continued regardless of these precautions with which we experimented.

The castings shrink because they are not properly fed, the risers being too small. To successfully produce solid brass castings of the diameters noted, it is necessary to use risers slightly greater in diameter than the castings. For example, the riser for a 2-inch diameter rod should be 2¼ inches in diameter. For castings up to 16 inches in length, mold horizontally. Place the riser at one end and carry it up about 6 inches above the highest part of the casting. To insure clean metal use a separate pouring sprue and carry the gate down the mold to the end of the casting opposite the riser end. Elevate the riser end 2 inches so that the metal will run from the sprue down the runner and into the casting at the bottom and it will gradually flow up into the riser. Break off the riser while the casting is hot. A bar, 4 inches in diameter may be made in the same manner, but better results may be obtained by using a cast iron mold and a sand head.

A Substitute for Charcoal for Brass Melting

Charcoal is exceedingly difficult to obtain and the price has advanced to $40 *per ton west of the Mississippi river. We use charcoal as a covering on yellow and red brass while melting in an open-flame furnace, and we would like to know whether there is a cheaper substitute for this material.*

Any organic substance that will burn to charcoal can be used in brass melting. Waste pieces of hard wood constitute an ideal covering since they burn to charcoal and while burning emit gases that protect the metal even better than charcoal. Many foundrymen use hard wood in preference to charcoal for this purpose. Another material that is suitable is tanbark. Coke dust also is used, but it is not to be recommended if the coke is high in sulphur. At present, powdered glass is employed extensively and some melters use nothing else.

Fusible fluxes are better than charcoal for protecting the metal from oxidation. They do not burn and they are not blown away from the surface they are designed to protect. The objection to them is that they are difficult to skim and frequently get into the molds with the metal. However, skimming can be facilitated by adding sharp sand to the flux before, which thickens the slag. Plaster of paris and salt also constitute a good flux, although it emits obnoxious fumes. Hard coal mixed with a small amount of dry clay also forms a good covering. When melting silver, sugar is frequently used for this purpose and would be equally as good for brass. However, its use is not to be recommended at the present time, owing to the sugar shortage.

An Aluminum Alloy For Aviation and Marine Motors

We are having great difficulty in casting an aluminum alloy for aviation and marine motor pistons. The specifications that we are to meet follow: Weight of alloy in pounds per cubic foot, 160 *to* 175; *tensile strength, pounds per square inch,* 25,000 *to* 30,000; *elastic limit,* 16,000 *to* 17,000 *pounds per square inch; melting point,* 1300 *degrees Fahr.; and compressive strength,* 125,000 *to* 130,000 *pounds per square inch. Kindly furnish us with a mixture of a coating to be applied to cores to be used in these piston molds suitable for aluminum work.*

To obtain a tensile strength of 25,000 to 30,000 pounds per square inch in an aluminum alloy with an elastic limit of 16,000 to 17,000 pounds per square inch, it will be necessary to add as much as 30 per cent zinc, which would make the alloy too heavy. We know of no alloy that has a compressive strength of 125,000 to 130,000 pounds per square inch, and since the compressive strength of manganese bronze is only approximately 28,000 pounds per square inch, we are of the opinion that some error has been made in these specifications as presented.

However, if ingot metal having these physical properties can be obtained, it would seem to be the best solution of the difficulty. The sample of the material submitted from the water jacket core has been deposited by the oil binder of the core, indicating that a linseed oil substitute is being used to bond the sand. We recommend the use of a fine grade of silica sand for the cores. No coating is required on cores for aluminum work. The pouring temperature should be less than 700 degrees Cent., depending upon the thickness of the casting.

Difficulties With Car Journal Bearings

We are making car journal bearings, some of which, when fractured, reveal dark brown spots about ½-inch in diameter in the center of the casting. The metal mixture contains copper, 73 *parts; tin,* 8 *parts; lead,* 12 *parts, and zinc,* 2 *parts. We use* 85 *per cent of scrap. The alloy has an excellent fracture except in the center.*

This trouble is attributable to internal shrinkage. This is caused by the draining away of the eutectic—the last part of the alloy to solidify—from between the crystals of the high melting point constituents of the alloy. The brown spots sometimes are found in the flange of the bearings as well as at the center of the back and the reason they have the brownish tint is because the crystals are of this color minus the eutectic which has drained away to other parts of the bearing in obedience to the law that liquids seek their lowest level. If a heavy riser, about 2 inches in diameter, is placed upon the back of one bearing and if the bearing is broken after the removal of the riser, the fracture will not reveal brown spots indicating that the trouble has been overcome. Of course, it is not economical to place a heavy riser upon the back of each bearing, but some practical manner of feeding can be devised. These brown spots or segregated areas are common in journal brasses of the better class of alloys and many castings are rejected because of this defect. The difficulty also may be remedied by the use of a better method of gating to feed the shrinkage internally.

How to Make Silicon, Phosphor and Manganese-Copper

We would like to know if the 88-10-2 *mixture requires a deoxidizer and if so, how much should be used? What percentage of the metals should be charged to obtain the correct formula as shown by analysis? How are silicon-copper, phosphor-copper and manganese-copper produced? Is phosphor-copper as good as silicon-copper?*

The 88-10-2 alloy does not require a deoxidizer if it is carefully made to prevent the copper from burning. It should be melted under charcoal with a small amount of salt. If it is necessary to use a deoxidizer, add not to exceed 0.25 per cent of phosphor-copper. The melting loss can be maintained at a low point by the use of a fusible flux such as sand, soda ash and lime, plaster of paris and salt, or ground glass in connection with charcoal. If 10.25 per cent tin and 2.20 per cent zinc are added, the resulting alloy should come close to the specifications when analyzed.

The best method of making silicon-copper is to fuse, in an electric furnace, glass, sand or quartz, retort carbon and granulated copper. It sometimes is produced by melting ferro-silicon and copper together, but the silicon-copper if so made always contains iron which is detrimental to the alloys in which it is used. Phosphor-copper is made by plunging cakes of phosphorus into a bath of melted copper by the use of phosphorizers. It is a dangerous procedure and we advise against attempting it. Phosphor-copper is better than silicon-copper as a general brass foundry deoxidizer since the use of silicon-copper is limited almost entirely to copper. Manganese-copper can be produced by melting together granulated ferromanganese and copper and allowance should be made for loss of about 20 per cent of manganese.

Does High Sulphur Fuel Cause Porosity?

We would like to know whether fuel oil, high in sulphur, will produce porosity in castings. Recently we cast bushings from an alloy of copper, 88 *per cent; tin,* 10 *per cent, and zinc,* 2 *per cent. The first lot of* 25 *castings were sound, but those made thereafter were exceedingly porous. Investigation developed that the metal in the defective castings had been melted with a new consignment of oil and that the copper also was a part of a new shipment. The oil contained from* 1.5 *to* 1.7 *per cent sulphur and the copper,* 0.2 *per cent arsenic. The defective melt was made from* 500 *pounds of new metal and* 500 *pounds of remelt. The pouring temperature was* 1975 *degrees Fahr. The mixture then was changed, a large amount of*

the new copper having been replaced with an 88-10-2 mixture in ingot form and the 500 pounds of remelt were continued in the charge. After this change the castings again were sound and we would like to know what brought this about.

It is difficult to fathom the connection between the sulphur in the oil and the arsenic in the copper. Three compounds of arsenic are formed with sulphur, namely, disulphide, known as realgar (As_2S_2), the trisulphide, known as orpiment or king's yellow (As_2S_3) and the pentasulphide (As_2S_5). When heated in the presence of air, these sulphides decompose into oxides of sulphur and arsenic. Replying to your first inquiry regarding the use of a fuel high in sulphur causing porosity, we wish to state that porosity certainly may be caused by this element, but it is not attributable alone to the sulphur, but to a combination of sulphur and oxygen, or what amounts to the same thing, namely, the absorption of sulphur by oxidized copper. The sulphur combines with the oxygen, either alone or in combination with copper and forms sulphur dioxide (SO_2). The reason that it is not advisable to use a high sulphur fuel is that in the event of any neglect in protecting the metal from oxidation, the castings are sure to be spongy. This is due to the fact that the sulphur has an equal opportunity with the oxygen to attack the metal and the combination of the two causes the trouble. When melting in an open-flame furnace with a high-sulphur fuel, it is advisable to use salt as a flux which will reduce the sulphur. Probably one of the best fluxes for this purpose is sodium hydroxide which combines with sulphur to form sodium sulphide. The latter takes up additional sulphur to form polysulphides. Sodium hydroxide is commonly known as lye and because it is a rather difficult substance to use as a flux, a mixture of soda ash, fine charcoal and chalk, might give almost equally good results.

How to Mark for High Spots

We are making brass molds which have to be scraped to fit at the edges and we would like to know what is the best material to use for marking to find the high spots. Red lead is unsatisfactory since it spreads too much. We have used smoke from resin and find it fairly satisfactory. However, we would like to know whether something better can be employed which can be applied more rapidly than smoke from resin.

Wet or oil half of the mold and dust a film of flour on the other half. When the mold is closed the flour will stick to the high spots on the oiled half of the mold.

Alloy That Will Resist Sulphuric Acid

We are experiencing trouble in obtaining the right mixtures for anti-acid cocks for 66-degree sulphuric acid. Will you kindly give us a good formula for this work?

A good formula for a sulphuric acid resisting alloy consists of 50 per cent nickel and 50 per cent copper. This alloy is difficult to cast in sand molds and will necessitate the use of some deoxidizer, such as manganese. The resistance of the alloy to the action of the acid is claimed to be materially increased by the addition of iron and tungsten to produce a mixture of approximately the following formula: Copper, 40 per cent; tungsten, 4 per cent; iron, 4 per cent, and nickel, 52 per cent. The foregoing alloys are resistant to sulphuric acid.

An acid-resisting alloy produced by a large valve manufacturer consists of copper, 86 per cent; tin, 9 per cent, and lead, 5 per cent. The addition of 0.25 per cent of 15 per cent phosphor copper is advisable to eliminate oxides as their presence in the alloy greatly decreases its power of resistance to the action of the acid; in fact, the value of the alloy, from an acid-resisting point, depends, to a greater extent, upon the skill of the melter than upon the composition of the alloy. A poor alloy from an acid-resisting viewpoint, well made, will be superior to an excellent alloy that is not properly produced.

What is Regulus Metal

We would like the formula for Regulus metal. We have an order specifying this alloy, but we are unable to obtain the mixture for it.

Regulus is a term used in metallurgy. It is applied to metals in various stages of recovery, but which still contain the same impurities contained in the original ore from which they were smelted. It is also applied to the non-fluid residue from liquid operations in the refining of scrap metals. This term first was applied by all chemists to antimony on account of its power to render gold brittle. Also, it is applied to antimony containing arsenic, lead, iron and sulphur, which is known as *regulus of antimony.*

Regulus of Venus is an alloy containing approximately 50 per cent antimony and 50 per cent copper. It is violet in color. However, this alloy is too brittle for practical application. In this instance, we believe, that this term has been applied to some bronze or brass alloy known only to the customer. We suggest that you obtain a sample of this alloy for analysis, if it is important that the peculiar properties of this particular alloy be retained, but if this is not essential it is probable that the customer might be satisfied with an alloy of an ordinary bronze composition.

Preventing Stools from Burning Onto Crucibles

How can we prevent a crucible from adhering to the stool of a brass furnace and from what material should a stool be made? While we are using coke-fired furnaces, we understand that stools are used under pots in oil-fired furnaces. We would like to use these stools, but we have been unable to find any material that will not burn onto the crucible.

The stool burns onto the crucible because the coke burns away around the stool and permits the latter to freeze onto the pot. In an oil-fired furnace the temperature around the stool is sufficiently high to prevent freezing and consequently, if a certain amount of slag accumulates between the stool and the bottom of the pot, it does not congeal and permits the removal of the crucible from the stool.

The stool should consist of a good grade of fire brick, the same diameter as the bottom of the pot, as otherwise it will cause the crucible to break. These stools also are made of the same material as the crucibles and may be purchased from crucible manufacturers. To prevent a stool from adhering to the pot, the coke should be poked down around the side of the stool to keep hot the pot bottom. A layer of finely ground coke placed on the stool also will prevent it from burning onto the pot.

Chilling Bronze Worm Gears

Specifications for bronze worm gears which we are making demand chilling to obtain density of grain and a certain Brinnel hardness. We understand that these gears may be chilled by graphite molds and we would like to have some information about this process.

The use of graphite molds is covered by a patent; however, cast iron molds also are being employed for chilling worm gears. This process is not patented and while it chills the gears successfully their use is not as convenient as the graphite mold. The proper degree of hardness is imparted to the gears by the use of tin and phosphorus as the chilling process will not make a soft bronze hard. The chill, by quickly solidifying the bronze improves the grain structure, thereby insuring a stronger metal.

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

FORMULAS FOR THE BRASS FOUNDRYMAN

Babbitts Used by Automobile Makers

New Way Motor

No. 1.

	Per Cent
Tin	88.00
Antimony	8.00
Copper	4.00

No. 2.

Tin	61.50
Antimony	10.50
Copper	3.00
Lead	25.00

No. 3 Special.

Tin	31.00
Antimony	10.00
Copper	1.00
Lead	58.00

No. 4 Special.

Tin	5.00
Antimony	15.00
Lead	80.00

Willys Overland

Tin	10.00
Antimony	6.66
Copper	3.33
Lead	80.00

Reo Motor

Tin	75.00
Antimony	10.00
Copper	3.00
Lead	12.00

FORMULAS FOR THE BRASS FOUNDRYMAN

Phosphor Bronze Alloys

Owing to the great demand for high grade phosphor bronze for castings for government work, the following results of tests of alloys made by A. Philip, admiralty chemist, are of value to all brass foundrymen:

No.	Character of Sample	Copper Per cent	Tin Per cent	Zinc Per Cent	Phosphorus Per cent
1	Bearings	84.50	14.50	nil	0.86
2	Piston packing ring	85.60	10.85	2.74	0.82
3	Gear Wheels	86.80	12.20	trace	1.43
4	Gear Wheels	87.00	12.00	trace	1.56
5	Piston packing ring	87.70	10.70	nil	0.97
6	Bearings	88.90	10.15	nil	0.82
7	Bushings	88.90	10.30	nil	0.77
8	Castings	89.00	10.00	nil	0.71
9	Bearings	89.70	9.40	nil	0.78
10	Bearings	89.20	9.60	nil	0.71
11	Bearings	89.10	10.10	nil	0.72
12	Sheaves	90.40	8.96	nil	0.73
13	Worm Wheel Rim	94.20	4.90	nil	0.96
14	Worm Wheel Rim	94.40	4.80	nil	0.98
15	Worm Wheel Rim	95.50	4.95	nil	0.95
16	Worm Wheel Rim	95.20	3.82	nil	0.86

The above alloys had the following physical properties:

No.	Tensile strength, pounds per square inch	Elongation, per cent in 2 inches
1	17,382	1.0
2	19,040	3.0
3	30,000	4.5
4	31,225	7.0
5	51,968	6.0
6	41,112	10.0
7	42,560	12.00
8	36,736	11.0
9	45,248	12.0
10	45,224	15.0
11	40,444	11.0
12	44,500	25.0
13	56,000	28.0
14	55,552	36.0
15	55,000	34.0
16	51,296	43.0

Producing Small Cores Cheaply in Quantities

To Combat the Present Labor Shortage, the Author Recommends the More Extensive Employment of Women in Core Rooms

By R E Kennedy

MODERN manufacturing, even before the pressure brought to bear on it by the present war, demanded that all processes and equipment which tend toward more efficient production, should be given careful consideration. Methods used in radically different lines of work often can be studied and then perhaps be applied to new conditions and produce good results. Manufacturers must keep pace with the progress of manufacturing in their own fields or soon find that their methods are of little value in meeting competition.

A manager, to get the most out of his plant, cannot rely entirely on past experience for the highest development of his work. The broad principles of management are the same in any line of manufacturing, and when these are known and each plant is studied and the methods analyzed in the light of these principles, good results are bound to result if the manager has the ability to grasp the full meaning of the principles and apply them to his plant. The management of the core room of a foundry, although not generally considered in the same class as many other plant departments, has to deal with the same principles which govern all other divisions of a manufacturing plant.

All factors of manufacturing must be governed by ultimate costs and when applied to the core room, may be classified as the workers, the materials, and the equipment and its arrangement. Managers of core rooms, when studying their departments from these three viewpoints will bring to light many things which they will want to improve. If they do not so study their work, they will continue in their old way of performing their part of the manufacturing processes and will not keep up with the demands for greater and better production.

Standardization, recognized by manufacturers as an essential feature of their business, brings good results to the core room. The use of unstandardized materials, methods and equipment in the form of varying core sands, binders, working of core boxes and use of miscellaneous plates, leads to constant trouble and loss of time.

The use of the special handling equipment like the lifting truck and its attendant special and standard platforms, which is now so common in general manufacturing, is just beginning to make its appearance in the core room, where it has many opportunities to effect economy.

Core rooms in which the production consists of large numbers of small cores lend themselves ideally

FIG. 1—CORNER OF A CORE ROOM WHERE CYLINDER AND CRANKCASE CORES ARE BEING MADE
The limited gangway for transporting sand to the benches, leads to confusion and loss of time. The equipment is good, but the layout is poor

Presented at the Boston meeting of the American Foundrymen's association.

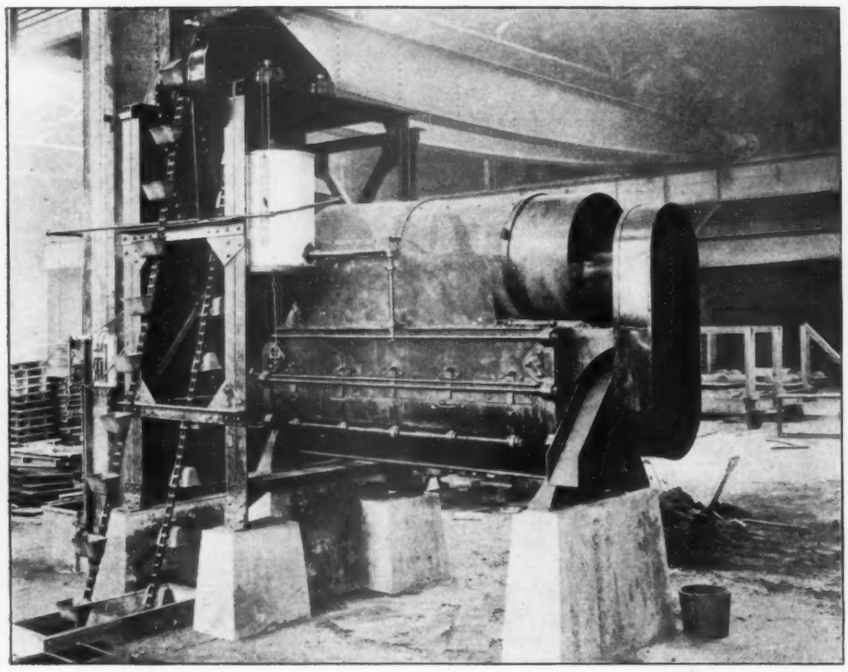


FIG. 2—SAND MIXER FOR THE ECONOMICAL AND ACCURATE MIXING OF LARGE VOLUMES OF CORE AND FACING SANDS

to the application of most of the methods employed in plants where stores used directly or indirectly for war purposes are made.

Core Room Labor—A Vital Foundry Problem

The question of the worker is as vital to the core room foreman as in any department of a plant and the same care has to be exercised in obtaining and training this class of foundry help as in other lines of work. The writer will not go deeply into this subject, but wishes to call attention to the fact that since men are being called on to perform military service and are being used in the heavier work of manufacturing, that the necessity for using women and girls will be felt as soon by the core room foreman as by the head of any other shop department. While some foundrymen already employ women in their core rooms, there are many others who could do so profitably on nearly all the operations in small core work. Women should not be asked to work under some of the dirty conditions prevalent in quite a few of these core rooms. If all foundrymen would only realize that they can produce better results with more contented labor, by having clean, well-lighted, well-ventilated surroundings, they would be in a position to use to advantage women in their core rooms without doing an injustice to this class of workers.

A number of core room foremen have tried out girls and women as coremakers and have become disgusted, while others who went about the proposition in a different way have found that girls, when properly instructed, turn out better small cores than boys or men employed in similar work. It has been the experience of those who have given women a fair trial that where the work requires deftness, a quick hand and a quicker eye, girls are more proficient.

Objection is also made to the use of women by some foremen because they say they have to have boys to carry the cores to the ovens and remove them from the ovens. This specialization of the work of the different operations is being found by the larger manufacturers to be the real solution of their problems of large output. Thus, instead of finding this division of labor a hindrance, they find it of great value. The coremaker who has to leave his bench to take his cores to the oven, get his plates and sand, loses more time in getting settled down to his work again than if the cores were carried away by cheap special labor and the sand, plates and dryers were also brought as his needs demanded.

Younger boys also will have to be used in larger proportions as the older men leave for other lines of work, and while this will tend toward greater specialization by confining them to a limited class of work, yet in fairness to them, they should be given a chance to learn as much of the varied character of the work as possible.

Laying Out for Straight-Line Flow

The location of the core room depends on several factors which are not always taken into consideration when building a foundry. These factors are as follows:

1.—The size of cores; large cores demand that the location of the core room be fairly near the point of use of cores in the molds. Small coremaking can be centralized so that the transporting of cores to the molder is less of a burden.

2.—The number of pounds of cores used per molder has a bearing upon the distance between the core room and the point of molding.

3.—Strength of individual cores, where cores are necessarily rather

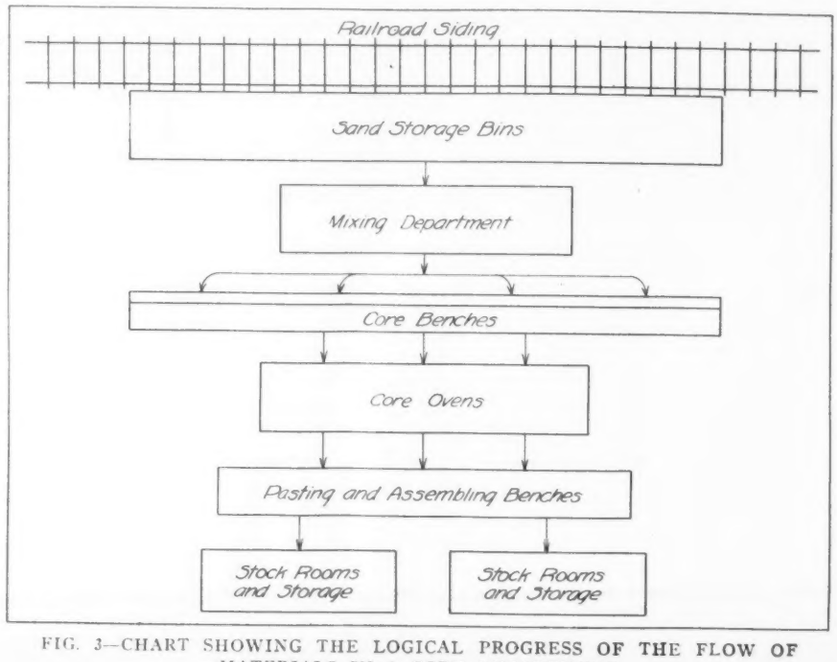


FIG. 3—CHART SHOWING THE LOGICAL PROGRESS OF THE FLOW OF MATERIALS IN A CORE DEPARTMENT

weak the longer hauling and repeated handling leads to high loss.

4.—Methods of handling; use of adequate transportation equipment over free gangways or overhead conveyors permits of greater hauling distances with less breakage.

Centralization of coremaking can be taken advantage of when the cores are small and the transportation facilities are good. Confining all the coremaking to one place reduces labor and floor space.

As in other lines of manufacturing, the core room has the same degree of adaptability to being laid out for the straight-line flow of material through the department from raw material to the finished product.

As usually seen, the average core room has not been laid out with an eye towards the easy and natural flow of sand from sand storage to batch mixer and through the operations in the core room to the foundry. This process is very definite and much advantage can be gained by closely studying the problem and working out the scheme which will best suit conditions. This is especially necessary when the space left for the core room work is limited and operators work close together.

All who are in any way familiar with core work have seen many examples of the evil resulting from narrow gangways and work going back and forth over the same path. Those who are designing a new layout have a much easier proposition in this respect than those who have to take over an old department and straighten out the kinks in the flow. As indicated in Fig. 3, all work should progress through the following steps, in the order named:

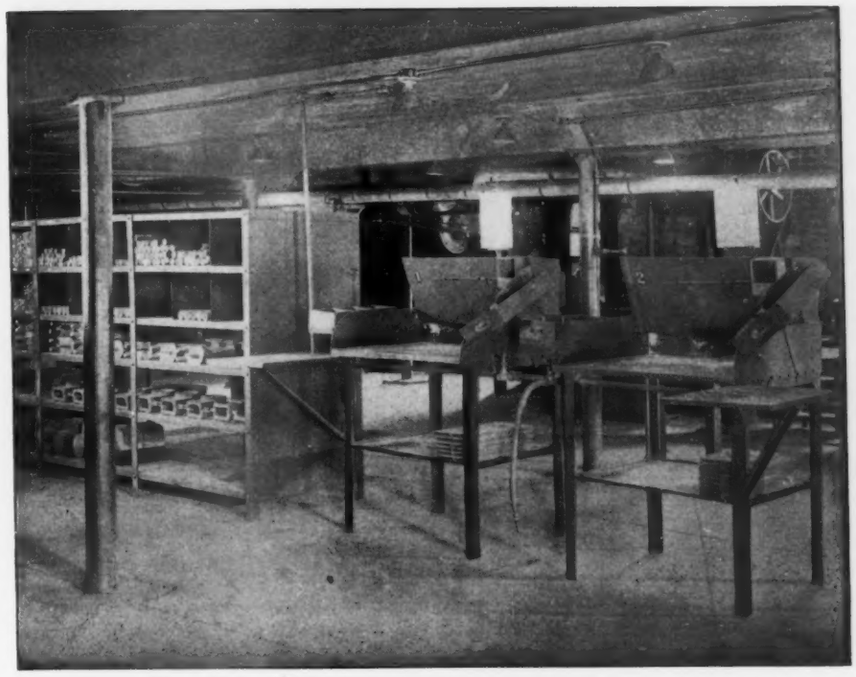


FIG. 5—SOME BENCHES OF A CORE ROOM PRODUCING SMALL CORES

Sand storage, batch mixer, storage for batches of various mixes, core bench, oven, pasting, blackening and assembling, redrying if necessary and stock storage.

Methods of Storing Sand

The writer has worked in some foundries where the coremakers often had to take a bucket or wheelbarrow and go several hundred feet to the sand sheds, get the sand needed and laboriously wheel or carry it to the core room. Even if it is possible to have railway facilities direct to the core room, the sand to be used for cores should be housed in bins or sheds located near the core shop. The most logical way to deliver the sand is to have it shoveled direct from the cars into convenient bins. If not so located and changes cannot be made, it will have to be handled by cars on an industrial track, by horse and wagon, or by the old familiar wheelbarrow. The core room then should be taken into consideration when laying out the foundry and given its place close to the railroad siding.

A mistake made by one company, operating a rather large Ohio plant, occurred because when the foundry was organized, the work was of such a nature that the number of cores made was small and the amount of sand used was correspondingly a small factor. Without considering that later they might desire to make work requiring a large number of cores, they located the core room on the side of the foundry opposite to the railway facilities where the iron and coke were being stored. What little sand was used was handled without difficulty in wheelbarrows through the molding floor gangways. Later, when the work was changed to take in a large amount of gas engine parts, the core room was enlarged, but the sand still had to be brought across the foundry in the same old way. Thus a large amount of labor was used in the hauling, and the handling of sand conflicted with the legitimate traffic on foundry gangways. This condition was so intolerable that the core room had to be moved to the opposite side of the foundry near the railroad siding.

Some foundrymen, realizing the ne-

FORM 102

INSTRUCTION CARD

SHOP LABORATORIES
FOUNDRY DEPARTMENT

FLOOR | BENCH | MACHINE | STATION 4

PART CORE SAND MIXTURE N°3
ARTICLE | PATT. NO.

STANDARD FLASK NO. | SPECIAL FLASK NO | CORE BOX NO. | CORE PLATE NO. | SAND MIXTURE NO. | WIRE, SIZE | RODS, SIZE | NO. LOOSE PCS. | NO. CORES

TOOL KIT NO. | RAMMER | FACING MXT. NO. | TACKLE N°2 Shovel N°A Wheelbarrow N°8-21" Riddle Quart Measure

ITEM	OPERATION ROUTINE	STANDARD TIME
	NOTE. CARD MADE OUT FOR TWO (2) #4 WHEELBARROW LOADS OF CORE SAND MIXTURE. IF A LARGER QUANTITY IS NEEDED USE QUANTITIES OF MATERIALS IN THIS SAME PROPORTION.	
1.	FROM SAND BIN NO. 1 OBTAIN 300 LBS OF SAND. DUMP INTO MIXING BOX.....	.0.05
2.	FROM SAND BIN. NO. 4 OBTAIN 200 LBS OF SAND. DUMP INTO MIXING BOX.....	.0.08
3.	RUN SAND THROUGH RIDDLING MACHINE WITH 1/8" RIDDLE.....	.0.03
4.	ADD THREE (3) QUARTS OF CORE OIL (GRADE #2) AND 2 GALLONS OF WATER....	.0.02
5.	RUN SAND THROUGH MIXING MACHINE.....	.0.06
6.	DUMP FROM MIXING MACHINE AND SHOVEL INTO MIXTURE BIN #3.....	.0.04
	TOTAL STANDARD TIME	0.28

FIG. 4—INSTRUCTION CARD

FIG. 6—DESIGN OF A POSTING, DIPPING AND ASSEMBLY BENCH WHICH FACILITATES THE WORK OF PREPARING CORES FOR THE MOLDS

cessity for having mixtures made as standard as possible, have installed equipment for drying the sand. Coremaking, like good cooking, has to be exact and if conditions vary from time to time, trouble is experienced in working the core sand in the boxes, due to sticking, being too dry, too weak or too hard when baked. Therefore, a sand of absolute uniformity in moisture content is necessary to begin with, and when damp sand is used directly in making mixtures, this absolute uniformity is not obtained.

One large foundry has the sand room so constructed that heating coils run through covered concrete passageways under the sand, drying it out. Cheaper installations, but which are more laborious to manipulate, consist of small sand heating stoves.

Dry Sand Important

Dry sand occupies less space than wet sand and it has been ascertained that if 10 per cent of water is added to clean lake or silica sand, there is an increase of about 40 per cent in volume. This should be taken into consideration when buying and making up core sand mixtures. When adding binder to sand of varying moisture content, the strength of the resulting cores will be different and the number of cores obtained from mixing a wheelbarrow load of dry sand will be greater than the number obtained when starting with a wheelbarrow of damp sand. Therefore, it is rather important to start with sand, always of the same moisture content and as dry as it is practicable to obtain it. With dry sand as a basis, binder and water in exact amounts can be added with every assurance that core sands of the same physical qualities will be turned out, day after day.

The mixing room of the average foundry, if there is one, varies to a great extent in size and in location as related to the straight-line flow. It should be located as directly between the sand storage and core room as possible, with easy passageway for trucks. A mistake, often made, is to place the mixing equipment either in some out-of-the-way bin or directly in the core room, where it is in the way of the coremakers. Conditions of a similar nature would not be tolerated in many of the other manufacturing departments. Neatness and order are today universally recognized as being essential to obtaining the highest possible output.

Measuring Equipment

As to the equipment needed in a mixing room, of necessity it will differ principally as the amounts of sand and binder which are daily mixed. It is essential that standard measuring instruments, either in the form of cups, boxes, buckets, or bar-

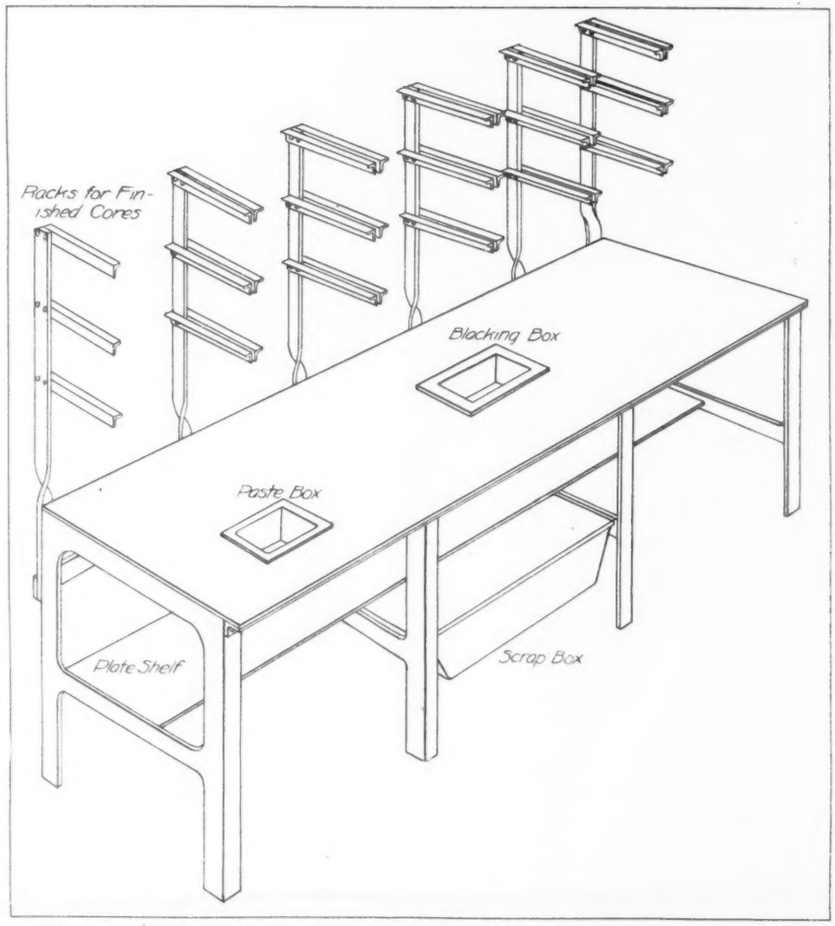


FIG. 7—LAYOUT OF A POSTING AND ASSEMBLY BENCH FOR SMALL CORES, SHOWN IN FIG. 6

rows and riddling and mixing machines be used. The employment of uncertain and varying sized measures leads not only to the use of excessive amounts of binders, but also to the occasional lack of the full amount needed. One defect is about as bad as the other. Where the usual grade of unskilled labor is used and indefinite instruction given, this variation is the rule. A cheap workman soon can run up the cost of mixing beyond what would more than pay for the employment of a careful man and provide him with means for exact measurements. The high cost of cheap mixing is occasioned by losses in handling poor cores and losses of castings. These losses are hard to trace to their source, for they occur throughout all the operations of assembling and molding.

Write Instructions

Combined with the use of these exact measurements should go instruction cards, Fig. 4, containing the necessary information to obtain these exact results, even when different men do the mixing. Verbal directions are easily misinterpreted and lead to many unfortunate circumstances, and, because of this fact some of the leading manufacturers have adopted as a slogan: "Don't say it, write it," which certainly is productive of good results.

FIG. 9—ELEVATING TRUCK FOR HANDLING CORES FROM THE COREMAKER TO THE OVENS AND THEN TO THE ASSEMBLY RACKS

This careful handling of materials leads to the possible success of one core room, while lack of it might lead to the failure of another, as the materials can be bought by one firm as cheaply as the other and the buying of the same equipment is as possible for one plant as any other. This puts it up to good management to introduce and make effective the methods which go to make one core room turn out a cheaper and better product than another.

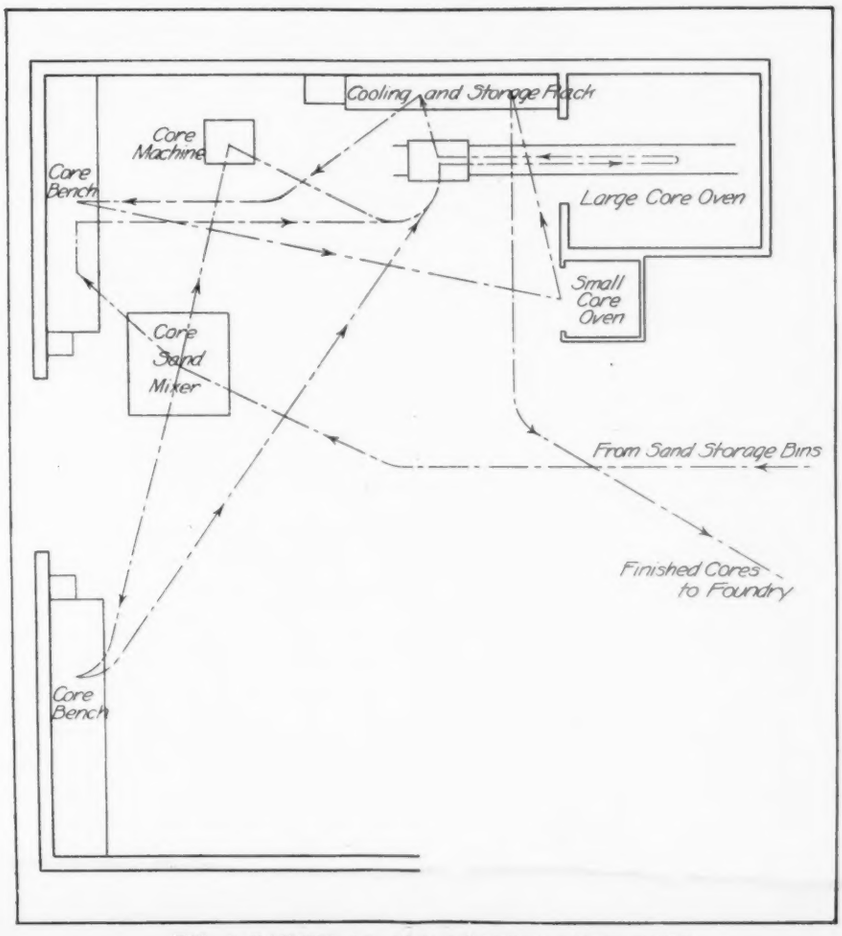


FIG. 8—LAYOUT OF OLD FOUNDRY CORE ROOM

Reducing Costs of Mixtures

Investigation into the possibilities of using cheaper binders and sand often leads to large savings, as is shown in one plant where core oil and lake sand had been used in the production of transmission case cores. The investigation brought to light the fact that a mixture of glutrin, lake sand and gangway sand could produce cores of the desired physical qualities at a saving of over 50 per cent of the former price per ton of sand mixed.

The number of cores per day from the coremakers is influenced a good deal by the character of the binder, for if it tends to stick to the box the maker cannot turn out as many as where a free working material is used. This sticking to the box is due, in many cases, to too great a percentage of binder and the trouble often can be eliminated by reducing the proportion of binder. This merely indicates one place for the core room foreman to investigate and find out what would be the best standard mixture to use to avoid these troubles.

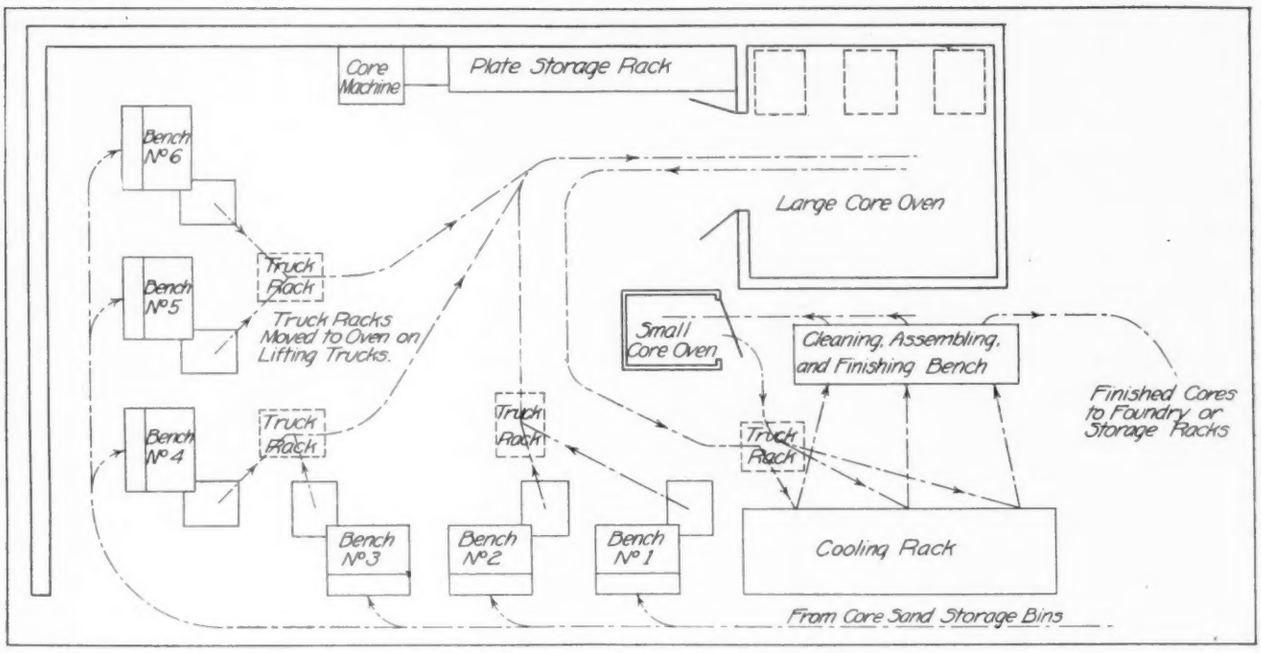


FIG. 10—LAYOUT OF NEW FOUNDRY CORE ROOM

This plan shows how the core room was rearranged to give the work a better routing. New benches were erected and the location of the equipment was changed

Accurate records should be kept of the costs per ton of mixing the different core sands and binder combinations and when this data has been observed for a while the importance of studying cheaper combinations will be realized. Many core room foremen do not know what the cost per ton of their different mixtures is and not knowing, are not impressed with the actual saving which can be effected by use of cheaper sands and binders. When the costs of these different mixtures are not known, very often an expensive sand is used where a less expensive one would produce as good results. Weekly summaries of the cost per ton in labor and materials used in the production of these different grades of sand will produce records for comparison and lead to the cutting down of core room costs. Air and electric riddles and small compounding mills prove of value to the core room having even a small output, as the increased quality of the sand mixtures go far toward cheaper materials and labor costs. By the use of a compounding mill one foundry was able to reduce its costs, as shown in the accompanying table, and others have been able to get even better improvements over their old hand methods. The use of the compounding mill effected a saving of $0.85 per ton. Hand mixing will not distribute the binder as thoroughly through the sand as mixing machines; hence more binder has to be used to produce as strong a core by hand mixing as by machinery. The accompanying table gives the results of using a compounding mill where it was desired to use some gangway sand in the mixture instead of all new sand.

COMPARATIVE CORE SAND MIXTURE COSTS WHEN USING COMPOUNDING MILL TO FACILITATE ADDITION OF GANGWAY SAND AND WHEN NOT USING MILL

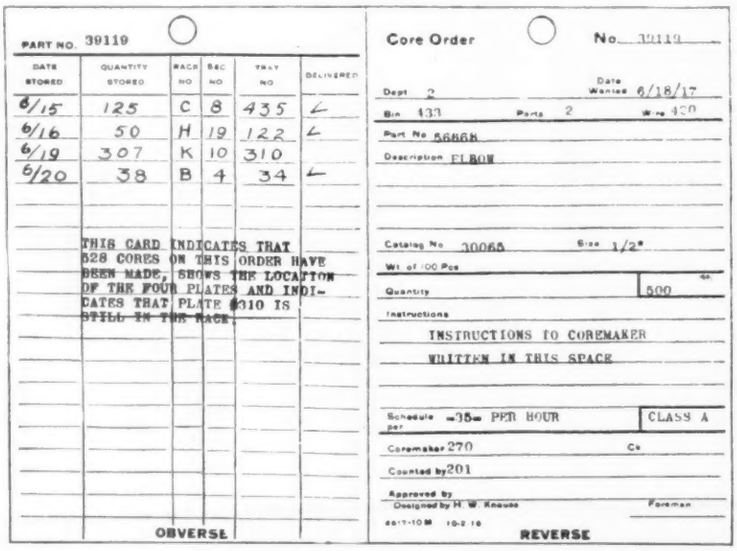
Cost When Not Using Mill

40 per cent or 800 pounds of new molding sand at $1.20 per ton	$0.48
40 per cent or 800 pounds new sharp sand at $0.60 per ton	.24
20 per cent or 400 pounds of old core or gangway sand 1 to 40 per cent or 50 pounds compound at $30 per ton.	.75
Total	$1.47

Cost When Using Mill

20 per cent or 400 pounds of new molding sand at $1.20 per ton	$0.24
80 per cent or 1600 pounds of old core sand 1 to 80 per cent or 25 pounds of compound at $30 per ton	.38
Total	$0.62

More extensive sand mixing plants are a necessity in the larger plants, handling many tons of sand mixture a day. Fig. 2 is taken from a photograph of a machine installation for mixing quantities of sand mixtures, where the sand is elevated, screened, water added and the mixture milled to a thoroughly uniform mass. These larger installations make a uniform sand mixture and the chances for variation are not as great as when smaller lots are prepared by hand. Having been mixed, the core sand is either taken directly to the core room or shoveled into bins which are temporary storage for the different grades of sand. Even in this part of the process of coremaking economies can be practiced if thought is given to the character of the work. The bins holding the stores of mixed sand either can be conveniently or poorly constructed. One automobile casting foun-


PART NO. 39119

DATE STORED	QUANTITY STORED	RACK NO	SEC NO	TRAY NO	DELIVERED
6/15	125	C	8	435	✓
6/16	50	H	19	122	✓
6/19	307	K	10	310	
6/20	38	B	4	34	✓

THIS CARD INDICATES THAT 528 CORES ON THIS ORDER HAVE BEEN MADE, SHOWS THE LOCATION OF THE FOUR PLATES AND INDICATES THAT PLATE #310 IS STILL IN THE RACK.

OBVERSE

Core Order No. 39119

Dept. 2 Date Wanted 6/18/17

Bin 433 Parts 2 Wt. each 450

Part No. 5666R

Description ELBOW

Catalog No. 30065 Size 1/2"

Wt. of 100 Pcs.

Quantity 500

Instructions

INSTRUCTIONS TO COREMAKER WRITTEN IN THIS SPACE

Schedule per .35¢ PER HOUR CLASS A

Coremaker 270 Co.

Counted by 201

Approved by Designed by H. W. Knouse Foreman

REVERSE

FIG. 11—ORDER FORM, OBVERSE AND REVERSE

dry in Detroit had this stock sand thrown into bins with sides about 4½ feet high. It was very hard for the laborers to scoop this sand out either by shovel or bucket and almost impossible to clean the bin thoroughly without climbing into it and working in a cramped position. If such bins are used they should have sliding or lifting doors at the bottom, where the sand can be shoveled directly from the floor, or where possible, have the bins left open at the front.

Inefficient handling of raw material and product increase the cost of production. In the smaller plants it is a paying proposition to handle the core sand from stock bins to mixer and core benches in wheelbarrows, for while extensive equipment in the form of monorail carriers or rail trucks might reduce the immediate costs of handling, the expense of installation and overhead charges would more than make up for saving of direct handling costs. Nevertheless, even in small plants, much can be done to systematize the delivery of core sand to the benches and do away with the necessity for the skilled workers to leave their benches in order to get their sand and do the mixing.

Orderliness an Important Factor

Crowded gangways, littered with core plates, riddles, boards and other trash go far towards making for inefficient delivery of materials. Orderliness is one of the first laws to be obeyed when high production is to be obtained. Fig. 1 illustrates a common condition where unbaked cores, sand, plates and like material have to travel over the same narrow gangway. The arrangement of core benches will also facilitate delivery of sand. Rows of benches ranged back to back with sufficient space for a gangway between them will allow the free passage of laborers with their wheelbarrows of sand, rods, etc., to pass without disturbing the coremakers or the cores setting on stands by the core benches. Benches with the hopper arrangement, as shown in Fig. 5, permit of a larger volume of sand being left on the bench at one time, yet without its being in the way of the worker or without having him disturbed when it is being delivered to his bench.

The charts shown in Figs. 8 and 10 show how the core room at the University of Illinois was rearranged for the better handling of materials and permitting the flow of work to progress in a systematic manner. Floor space in this case was limited and the highest ideal of straight-line flow could not be reached, but the large amount of crossing and recrossing of the paths of materials was eliminated. Core sand was delivered from the mixer to the benches into hoppers from the back. Rods, wire and plates were also delivered to the benches by using this same gangway. This prevented much traffic from interfering with the removal of cores from the benches to the ovens. The coremakers placed their finished plates of cores on elevating truck racks, similar to the type shown in Fig. 9. This type of truck furnishes the means for the continual use of large truck ovens, where, when using rack trucks on stationary tracks, the oven cannot be utilized while the cores are being loaded into the rack and when they are being removed.

The continuous use of the ovens is an important factor where trucks are the means for holding the cores in the oven. Where ovens have to stand idle while their truck racks are being loaded and unloaded, just twice as much oven equipment as is required is being used.

When using steel racks in connection with these elevating trucks as many racks as can be utilized are on hand and then some are placed at the core benches and are being loaded, while yet another set can be in the oven with baking cores, with a third set with baked cores being unloaded at the assembly benches.

Where the racks can be placed back of the coremaker's bench they will produce the best results. Then all the coremaker has to do is to turn around with his finished plate of cores, place them on the rack and begin a new plate. When the rack is filled it can be removed to the oven for baking and an empty rack set in its place. This will eliminate the many trips to the ovens of the coremaker and the subsequent hunting for an empty oven shelf. In a foundry studied by the writer, the time wasted by the coremakers when taking each plate to the oven amounted to more than an average of two minutes per plate. This two-minute loss on each plate could have been reduced to a six-minute loss on 40 plates by using the portable rack.

Handling Finished Cores

The employment of the elevating truck requires that the core room floor be in good condition, as the spoilage of delicate green cores may be considerable. Special layouts with rack cars between rows of core benches are successfully used in some of the larger core rooms, but the system is not as flexible as the elevating truck system.

The use of the drawer type oven and rail truck type will still be the most efficient in some cases, but the management should seriously consider all methods, because additional labor and extra oven equipment should be eliminated if possible. These types must be studied to determine which method will give the most continual use of the ovens, the least amount of handling and the greatest production with the least floor space and smallest number of men.

To insure oven work of the highest degree of uniformity, ovens must be so constructed that their temperature can be maintained at a constant point. This means they must be well insulated and as free from uncontrolled air as possible.

Oven Temperature Control

To be sure that this constant temperature is maintained, recording thermometers should be installed to enable the oven tenders and management to know the temperature at which the oven is being kept. The thermostat used in connection with the oven flues or dampers will assist in obtaining an even degree of heat by providing mechanical means of damper control. Mechanical regulation, when working properly, will always insure greater accuracy of baking than when the regulation is left to the judgment of laborers of the class prevalent around a foundry core room. While in some cases, attempts at mechanical control have been a failure, it is not to be denied that the best control will only be obtained when some such means are employed.

When running a standard mixture, it is a comparatively easy matter to find the temperature at which the cores can be baked quickest without burning the outside before the core has been thoroughly baked inside. Knowing this temperature, the ovens can always be kept worked to their highest degree of output. This is especially necessary when large quantities of cores have to be handled, for when the cores require too long a time to bake, it will mean extra oven equipment. The usual reason for failure in thus controlling the temperature is not due to the general method, but to faulty mechanical installation and poor instruction or knowledge on the part of the management. In one large core room it was found that the best results from a continuous oven system for certain cores was obtained when a temperature of 525 degrees Fahr. was maintained. For the ovens used for baking cylinder barrel cores a temperature of 500 degrees Fahr. maintained for 2½ hours gave the best results. In a radiator foundry running about 35

tons of core sand a day it was ascertained that when using recording thermometer control, that 380 degrees Fahr. for the first hour followed by two hours of steady heat, then three hours of slow cooling, gave the best results. The varying of the temperature was obtained by using forced draft.

Where large numbers of cores are being made the work of smoothing, pasting, blackening and assembling can best be divided into separate operations so that special workers each have one or two operations to perform.

Well arranged benches are a necessity where the workers can have the cores brought to them, placed conveniently near and have stools to sit on, for on this class of small work there is no necessity for the assemblers to stand.

Fig. 6 shows a small, well-arranged bench developed at the University of Illinois foundry for the workers pasting, blackening and assembling small cores. The cores from the oven are set in racks just back of these workers and to get their supply of cores they merely turn around for a plate of unworked cores. Pots holding paste and black wash are set into the bench, as shown, being located for the convenience of the worker and out of his way. When the cores are finished they are set on plates in the rack at the back of the bench. From here they are carried away by another worker who attends to the redrying oven. The finished, assembled cores are taken direct to the core storage or the foundry.

Progressive Finishing of Cores

If the benches are so arranged that successive operations can be performed by the workers sitting next to each other or across the bench from each other, the cores can be passed directly from man to man, eliminating the necessity for storing in trays and carrying or hauling to the next operation. This progressive finishing of cores is followed by several of the larger automobile foundry core room organizations.

The cores having been finished and assembled, they can best be stored in trays or boxes or on boats where they can be left until required in the foundry and then carried in these same trays direct to the molder's floor.

A large loss of cores occurs in many foundries because they are taken to the foundry on poorly constructed trays or platforms, left in the way, and if not used, they remain there to be broken by placing boards and flasks on them. This occurs in practically every foundry, as it seems almost impossible to make the molders realize that cores in the foundry represent money.

Order and Stores Control

The following description of the method of core routing and core storage used by the Mueller Mfg. Co., a large manufacturer of brass plumbing goods, will show how it has attempted and successfully executed a plan for the control of the making of cores in the right quantity and storing them until ready for use. Hampered by a small core room, formerly a part of the foundry which, like Topsy, "just grew," as increased production was called for, it has made a special effort to produce large quantities of small cores of the very best quality. To get this quantity meant specialization of labor, careful routing of work, and well planned storage where the numerous kinds of cores could be found when needed.

Girls are employed as coremakers because they have been found to be more adept at this small core work than boys or men. The writer was pleasantly surprised at the intelligent class of girls employed as compared to the class in several other plants. This has been made possible by the management endeavoring to maintain clean surroundings.

Factory orders made out in duplicate, Fig. 11, go to the man in charge of the core box storage, who then gets the desired box from its rack and places it with the order on a rack accessible to core room foreman. Rush orders and the corresponding boxes are immediately sent to the core room foreman in his office.

Each core has an estimated rate per hour, divided into three classes, *A*, *B* and *C*, according to their intricacy, the more intricate being classed as *A*, less intricate as *B*, etc. The coremakers are rated according to their skill, as *A*, *B* or *C* class, and are paid a corresponding rate per hour, which they get without question, no matter how much they turn out.

If, as shown on the sample card, Fig. 11, the job is scheduled *Class A*, at 35 cents per hour, or $3.15 for nine hours work, and the coremaker at the end of the day has produced a total of 350 or 35 above the schedule, she is paid 11 cents extra. This rate of 11 cents is paid for the scheduled number of cores per hour which are turned out in excess of the standard for *Class A*. If the cores are rated in *Class B*, the coremaker is paid 10 cents for each scheduled hour's work in excess of the standard and for cores in *Class C*, 9 cents is paid.

With the schedule rates per hour and information obtained from his assistant, the foreman at the start of work in the morning and afternoon, knows what work can be made each day, and then, from his orders, he lays out work in advance for the coremakers. The core boxes to be worked are marked with the coremaker's number and sent to a station supervised by a workman whose duty it is to get ready the wires and dryers needed. These are collected and when the coremaker is ready to start on the new work, she proceeds to a card rack, obtains her duplicate of the work order, goes to the bench where the jobs have been laid out, obtains her box and wires, while the dryers are carried to her bench.

Inspection of Cores

As she finishes plate after plate of these cores, she enters the number made on the back of her core order, Fig. 11, which gives her information, telling her when the order is finished. Each plate has placed on it an iron tag with the part number corresponding to that on the work order. The green cores are carried to the ovens by a boy whose duty it is to do this work. The ovens are charged by a man who regulates the baking and removes the cores to cooling racks. From the cooling racks they are taken to the benches where girls clean and smooth them with graphite. The finished cores are next taken to the inspecting and checking rack. At this point the inspector notes on the back of the original order the date, the number in the tray, the rack and section number, when it is to be stored until taken to the foundry, and the tray number. The iron tag which has followed this plate of cores through the different operations is removed at this point and a paper tag is placed with the cores.

When the entire number of cores have been finished for the order, this core order card is placed in a rack where the laborer whose duty it is to take the cores to the molders can have access to it. This man then knows where to obtain the needed cores, and as he removes them to the molding benches, checks off on his work order card the number of the plate delivered.

This system provides for having the needed cores on hand when wanted and in a known location. It also provides against dispute between the foundry and core room as to cores made and delivered, supplies the information for the payment of bonus to the workers, and checks losses during the progress of cores from the

(*Concluded on page* 182)

Making Hand Grenade Castings for Uncle Sam

Molding, Casting, Cleaning and Annealing Practice of a Milwaukee Malleable Iron Plant That is Producing 18,000 Grenades Daily

By A M JONES

FOR several centuries the hand grenade has been one of the important missiles of warfare, but not until the present terrible European conflict did it assume a place of almost ranking importance. Trench fighting, accompanied by frequent raids, makes the hand grenade an almost indispensable weapon, and in the hands of the moppers-up it is a terrible means for the destruction of human life. Since the beginning of the war many types of hand grenades have been developed, but the models used by the Central Powers and Allies differ considerably in design. Unlike the rifle grenade which may be propelled several hundred yards, the hand grenade, as its name implies, is thrown by the grenadier and is mainly intended for close-up work, particularly where the opposing trenches are not widely separated. At the end of the seventeenth century hand grenades were used in warfare, before muskets were generally employed. These grenades consisted of hollow balls of iron or other metal, which

FIG. 1

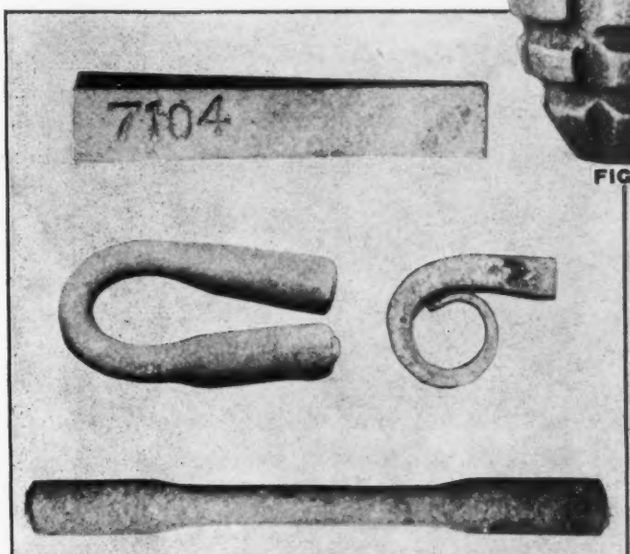


FIG. 2

FIG. 3

FIG. 4

FIG. 5

FIG. 1—HAND GRENADE WITH EXPLODING DEVICE ATTACHED. FIG. 2—TEST WEDGES SHOWING THE MALLEABILITY OF THE IRON. FIG. 3—ANNEALED GRENADES WHICH HAVE BEEN BATTERED BY SLEDGES. FIG. 4—SECTIONS OF HAND GRENADES OF UNIFORM WALL THICKNESS; *A* AND *B* ARE HALVES OF A GRENADE BROKEN IN THE HARD AND *C* AND *D* HAVE BEEN CUT WITH A SAW. FIG. 5—GRENADE CASTING FRAGMENTED BY GOVERNMENT INSPECTORS—NOTE THE UNIFORMITY OF THE FRAGMENTS

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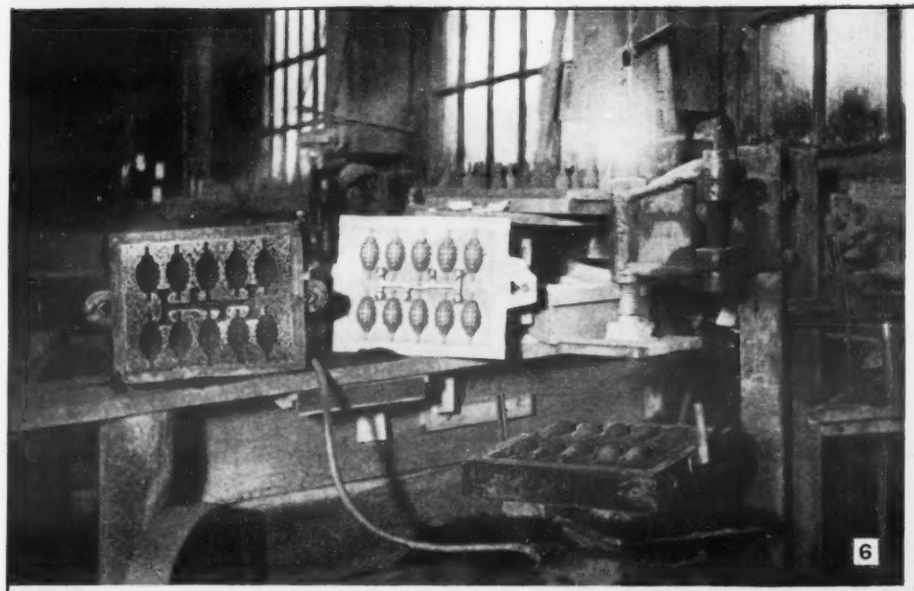


FIG. 6—COPE AND DRAG HALVES OF HAND GRENADE MOLD, THE MATCH-PLATE WITH 10 PATTERNS ALSO IS SHOWN FIG. 7—THE APPEARANCE OF SEVERAL HAND GRENADE FLOORS AFTER 4½ HOURS WORK. FIG. 8—ANOTHER VIEW OF THE SAME FLOOR SHOWN IN FIG. 7. FIG. 9—A CORNER IN THE GIRLS' CORE ROOM. ALL GRENADE CORES ARE MADE BY FEMALE LABOR

were filled with powder. At first it was the practice to assign only a few soldiers to a company, trained in throwing grenades, but about 1670 the French and British organized whole companies of grenadiers. Early in the 19th century the use of the hand grenade was discontinued almost entirely due to the development of the musket, but in the Russian-Japanese war it was used effectively, particularly during the siege of Port Arthur. The grenades employed at this time were of a modern type and were filled with a high explosive.

Millions of Grenades Being Cast

In the trench warfare now being conducted in Europe, both hand and rifle grenades are being used extensively, and to provide amply for the requirements of our army, millions of these missiles now are being cast

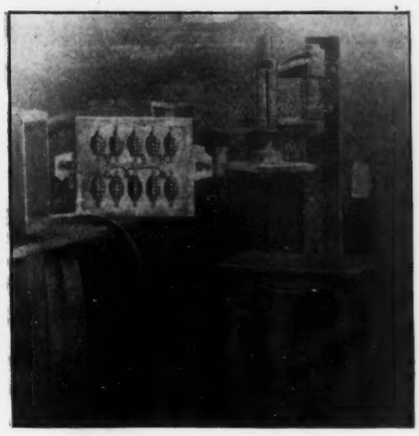


FIG. 10 — A VIEW OF THE POWER-OPERATED SQUEEZER MOLDING MACHINE ON WHICH GRENADE MOLDS ARE MADE

in the foundries of this country and are being machined and finished in other manufacturing plants. Since malleable cast iron possesses the most satisfactory shattering properties and is broken into the largest number of destructive pieces when the grenade is exploded, this metal has been adopted by the ordnance department of the United States army in preference to cast iron or steel.

In the distribution of orders for hand grenades, the Federal Malleable Co., West Allis, Wis., received a large contract for body castings of the latest type, as illustrated in Fig. 1. It will be noted that unlike the rifle grenade, the hand type is corrugated on the outside, thereby providing definite lines of weakness and strength in the casting. The government specifications provide, that when tested, a grenade shall not break into more than 150 pieces, and all of the castings thus far produced by the

FIG. 11—TEMPORARY STORAGE RACKS SHOWING THE METHOD OF PILING HAND GRENADE CORES

Federal Malleable Co., have met this requirement. Every heat of metal is carefully analyzed and the chemical contents are known before the castings are charged into the annealing ovens. For ascertaining the physical properties, test wedges are cast from each heat and are given respective heat numbers. Some of these test bars are shown in Fig. 2. The wedge that has been curled reflects the high malleability of the metal. The round test bar is pulled for strength and the iron regularly has developed tensile properties ranging from 48,000 to 55,000 pounds per square inch with elongations which range within the narrow limits of from 11.5 to 12.5 per cent.

Fig. 3 further illustrates that only high grade iron can be used in the production of hand grenades to comply with the rigid specifications. The grenades shown were subjected to repeated blows from heavy sledges, but could not totally fractured. Halves of grenade body castings, split transversely and sawed laterally, are shown in Fig. 4. The grenade which was split lengthwise, the two halves of which are indicated by *A* and *B*, was fractured in the hard and before annealing, while the halves, *C* and *D*, were cut after annealing. These views are intended to indicate the uniformity of wall thickness of these castings. Effective fragmentation cannot take place if the walls

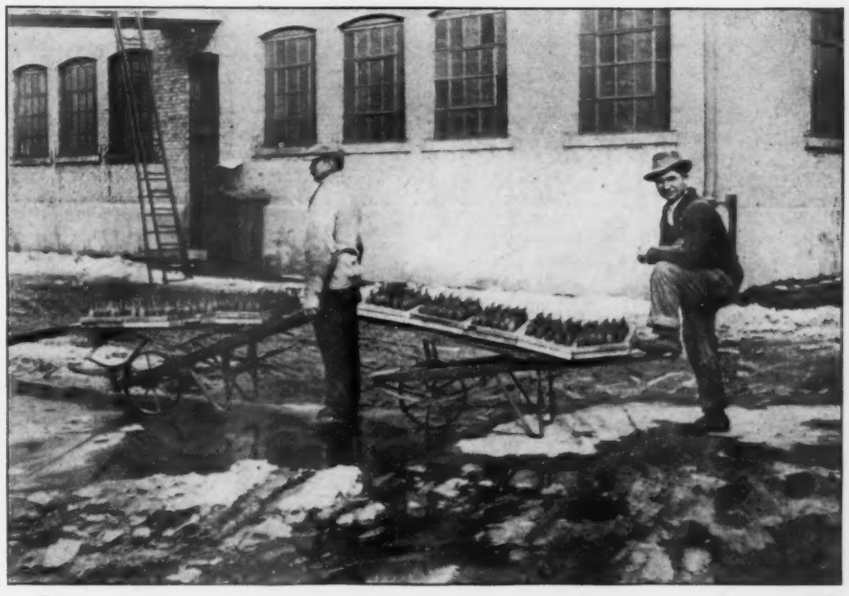


FIG. 12—WHEEL BARROWS PROVIDED WITH SPRINGS FOR CONVEYING THE HAND GRENADE CORES FROM THE CORE OVENS TO THE MOLDERS

FIG. 13—HARD IRON INSPECTION BENCH

are not exactly of the same thickness and castings showing the slightest variance in this respect are rejected.

Fragments of a grenade shattered by the chief inspector of the government are illustrated in Fig. 5. The specifications provide that 90 per cent of the casting by weight must be recovered and this has been done in every test of grenades made at the Federal Malleable Co.'s foundry. Fragmentation tests are made almost daily and the fragments illustrated represent an average result. The specifications provide further that the grenade castings must weigh 16 ounces with a plus or minus allowance of one ounce. The castings made at the Federal plant exceed one pound by one-half ounce only and thereby come within safe limits of the requirements of the specifications.

Output Averages 18,000 *Daily*

When the contract for these grenade castings was received a department of the plant was specially equipped to facilitate production. Production now averages over 18,000 body castings daily, which is the output of only 12 molders. The molds are made on power-operated squeezers designed and built by the Federal Malleable Co. A view of one of these machines with a grenade matchplate at the left, is shown in Fig. 10. Ten castings are made in a mold and the floors now average 160 molds per day, or 1600 castings. The record floor, without overtime, was 176 molds, or 1760 castings from one man in one day. As the output per molder is steadily increasing, it is believed that this record soon will be broken. For a malleable shop, the weight of castings produced daily per molder, is considerably above the average. To facilitate pouring-off, bull ladles mounted on wheels are employed, one being provided for every two molders.

Aluminum matchplates, with the patterns of ten grenades on each are used on the squeezers. Split brass patterns are mounted on the matchplates, one-half of the pattern being on each side of the plate. The brass patterns were machine turned and micrometered before being mounted to insure absolute roundness. The cope and drag halves of a grenade mold, with the cores set in the drag ready to close, are illustrated in Fig. 6. The matchplate shown in this view as well as the cope, clearly outline the method of gating. With the exception of a small junction fillet in the drag, the entire gate is in the cope. The gate is built-up to feed the castings and that section of the gate joining the castings is elliptical. This method of gating almost entirely eliminates shrinkage defects.

Molding Machine Insures Big Output

The efficiency of the type of power-operated squeezer employed is reflected by the large floors of grenade molds, representing only 4½ hours work, shown in Figs. 7 and 8. All of the metal for grenade work is melted in one furnace, which is of the ordinary coal-fired, air type. The first heat is poured at 7 a. m., and the second at 12:30 p. m.

Satisfactorily and accurately coring the hand grenade molds was one of the difficult problems that had to be solved. In addition, these cores must be produced in large numbers and adequate facilities had to be provided for doing this work expeditiously. The acceptance or rejection of the casting depends upon the exactness of the core and the care exercised by the molder in setting it. The core department of the Federal Malleable Co. was not of sufficient size to provide room for the production of grenade cores, and since sufficient time was not available to erect a new building for this purpose, a wooden structure on the property was partially reconstructed and enlarged to serve as the grenade core shop. Rest and lunch rooms are provided and the ovens are located separately in a room, apart from the female coremakers. Twenty girls are employed for making grenade cores, practically all without previous coremaking experience when they were engaged.

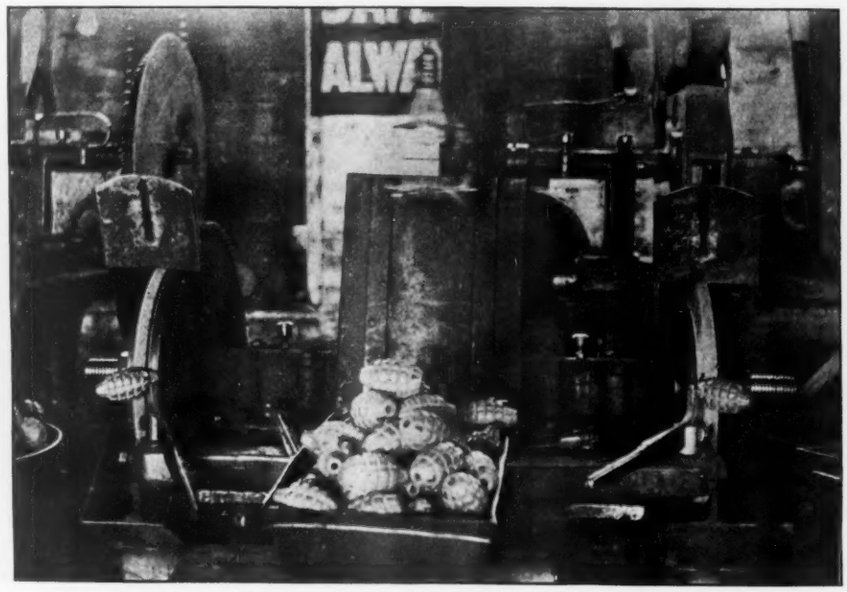


FIG. 14—VIEW OF THE TWO WHEELS WHICH GRIND THE ENTIRE DAY'S OUTPUT

With the exception of the laborers who bring in the sand and carry away the cores, none of the male employes is permitted to enter this department. The cores are made in cast iron, machined core boxes, of three chambers each, and each chamber is machined to a high degree of accuracy. The core mixture consists of silica and bank sand and the cores are not vented. The silica sand opens up the cores sufficiently to make venting unnecessary and the blowing of the cores never occurs. The mixtures are prepared in a machine installed by the Blystone Mfg. Co., Cambridge Springs, Pa. Fig. 9 is a section of one corner of the core room with the newly made cores on the iron driers ready to be delivered to the ovens.

Girls Make 1000 *Cores Daily*

The girls average 1000 cores daily, the record output being 1300. Since overtime for female labor is not permitted by the laws of the State of Wisconsin an adequate force had to be provided and a large stock of cores is carried to guard against emergencies. Fig. 11 shows a section of temporary storage racks and also illustrates the method of handling cores in quantity. After baking, the cores are removed from the driers by boys who also inspect them and set them into holes drilled into specially prepared coreboards by which the cores are delivered to the molders. Each board has a capacity of 55 cores. The coreboards and their loads of cores are transported to the foundry on special trucks provided with springs, designed and built by the Sterling Wheelbarrow Co., West Allis, Wis. These trucks with loads of cores are shown in Fig. 12.

FIG. 16—FINAL INSPECTION BY GOVERNMENT INSPECTORS

After shaking-out, the grenade castings are tumbled in the hard. They are next delivered to the sorting bench, Fig. 13, where they are carefully inspected by the company's employes and all defectives are scrapped. The sound castings are then delivered to the grinders where they are ground in the hard. For the purpose of applying the proper force on the castings and against the grinding wheels, the special device actuated by a lever, shown in Fig. 14, has been designed. The entire daily output of over 18,000 castings is ground by two men on two wheels. Another marvelous feature of this performance is the fact that no overtime is incurred in this department in disposing of the day's output.

After being ground, the castings are packed for annealing. A battery of six ovens is constantly employed and the grenade castings are annealed in the same ovens with other castings produced in this shop. The ovens are coal-fired and the temperatures are controlled by pyrometers furnished by the Industrial Instrument Co., Foxboro, Mass. Platinum-rhodium couples are used independently in each oven and readings of each oven are taken every hour, both day and night, thereby insuring absolute temperature control. After annealing the castings are sand-blasted in a sand-blast barrel, Fig. 15, installed by the New Haven Sand Blast Co., New Haven, Conn. Steel grit is used instead of sand-blast sand. Additional equipment for sand-blasting will be installed which will eliminate night work now necessary to clean the large daily output. After cleaning, the castings are dumped on a large bench, Fig. 16, where they are subjected to their final inspection by government inspectors. They are then bagged, loaded and shipped to the plant where they are to be machined.

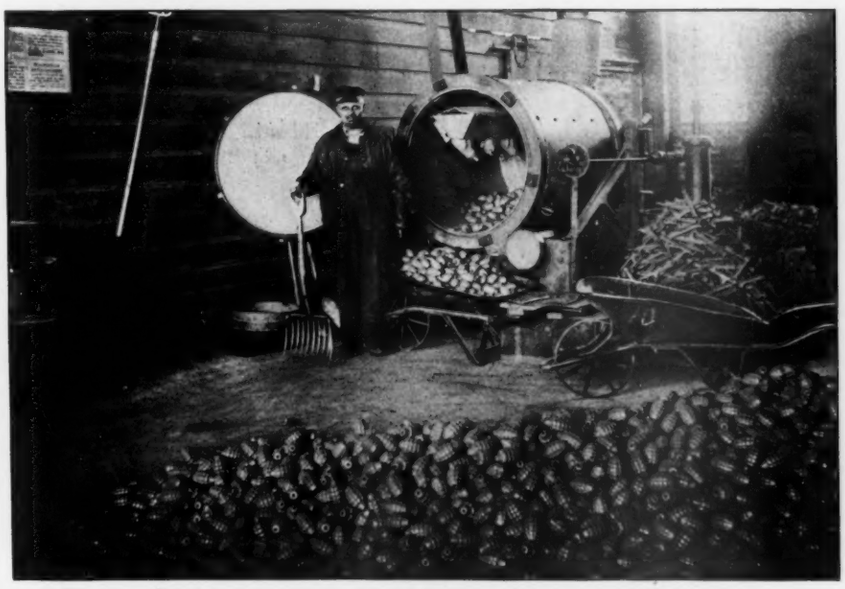


FIG. 15—SAND-BLASTING ANNEALED GRENADE CASTINGS BEFORE DELIVERY TO THE GOVERNMENT INSPECTORS. THE OPERATOR ONLY HAS ONE ARM, YET HE WORKS EFFICIENTLY

Fragmentation Tests

For the purpose of making fragmentation tests a shed has been built in which the grenades are exploded. The grenade to be tested is placed inside of a steel drum filled with sand, and which is heavily weighted. The steel drum is enclosed in a box made of heavy planks and which is thoroughly reinforced. After the grenade has been exploded the contents of the steel drum are riddled.

The sand falls through the meshes of the riddle and the fragments of the grenade are retained in the screen and are recovered.

Producing Small Cores Cheaply in Quantity

(*Concluded from page* 176)

makers to the foundry. It provides an excellent, controlled method of having the work flow through the sequence of necessary operations from the receipt of the order to delivery to the foundry.

Summary of Flow of Work

Each person has his or her specified duty and becomes a specialist in that work. The summary of the flow of work is as follows:

1.—Order received at box vault.
2.—Order and box delivered to foreman.
3.—Day's work scheduled by foreman.
4.—Wire and dryer man prepares boxes of wires and dryers.
5.—Coremaker has sand brought to bench and receives box and dryers.
6.—Green cores taken by laborer to oven.
7.—Oven tender bakes and removes cores to cooling rack.
8.—Laborer supplies girls who clean and blacken cores.
9.—Finished cores inspected and counted.
10.—Finished cores stored in racks of numbered sections.
11.—Cores removed to foundry from storage rack by special laborer as they are needed by molder.

Some interesting points were observed in this plant in addition to the control of output. A special paste is used on the wires, which, while holding the wires in place, allows them to be removed from the casting. When they are not bent while being removed from the casting, they are ready for use again.

A special wire-cutting and forming machine is operated by one man, who furnishes not only all the intricately bent wires for this works, but also for the Canadian plant. This machine automatically cuts and binds the wires which are used in the large number of valves, tees, faucets and other castings produced. Dies for the different shaped wires are easily slipped into place, reducing the cost of cutting and bending to a minimum.

By the use of special sand mixtures many complicated cores are made without the use of dryers, as the mixture gives an extremely strong green core and yet cleans out of the casting with a minimum of expense. At the same time, these cores are accurate as to size, for the type of work demands that they be so. Most of the boxes used are cut out of solid blocks of steel, giving the cores an accuracy which cannot be obtained from wooden or cast metal boxes. This method of cutting the boxes from steel makes an initially high box cost, yet the results justify this expense.

This careful control of the core output is in direct contrast to one other large automobile plant visited by the writer, where all orders were transmitted from office to foreman by word of mouth, and the foreman in turn gave his men verbal orders. The cores, when removed from the ovens, were placed around the shop in gangways on bottom boards, under benches and some on unmarked racks. Many orders were duplicated and cores often were lost by the time the molder was ready for them and others had to be made. Others were broken because they were left in passageways, where wheelbarrows and trucks would often overturn the board on which they rested. The work of pasting, trimming and blacking the cores was scattered all around this foundry, resulting in much confusion in handling the work.

Such conditions are these do not pay, yet they can be seen in a large number of foundries. It behooves each foreman and manager to make his department a subject for analytical criticism and then to do such constructive work as will keep the shop on a production basis. Find the best arrangement of equipment, put in all the labor-saving equipment which will actually reduce costs, specialize the labor to perform its work efficiently and use mixtures which will give the best results at the cheapest cost.

Personal

H. P. Curtiss, 120 Milk street, Boston, has been appointed New England representative of the Clarage Fan Co., Kalamazoo, Mich.

A. F. Ausman has been appointed Chicago district manager of the Nagle Corliss Engine Works, Erie, Pa. He formerly was vice president of the McMasters-Carr Supply Co., Chicago.

Eliot A. Kebler, secretary and treasurer of the Matthew Addy Co., Cincinnati, pig iron merchants, has resigned to become president of the Fawcus Machine Co., Pittsburgh, to succeed the late Thomas Fawcus.

Edward P. Quinn has resigned as manager of the foundry of the Turner & Seymour Mfg. Co., Torrington, Conn., to become superintendent of the foundry operated by the Bilton Machine Tool Co., Bridgeport, Conn.

G. M. Carter, formerly general manager of the Adams Truck Foundry & Machine Co., Findlay, O., has resigned that position to become general manager and vice president of the Adams Axle Co.

H. J. Klaer, formerly general manager of the Penn Seaboard Steel Corp., Philadelphia, has been elected second vice president, in charge of castings production, to succeed C. E. Middleton, who was elected vice president.

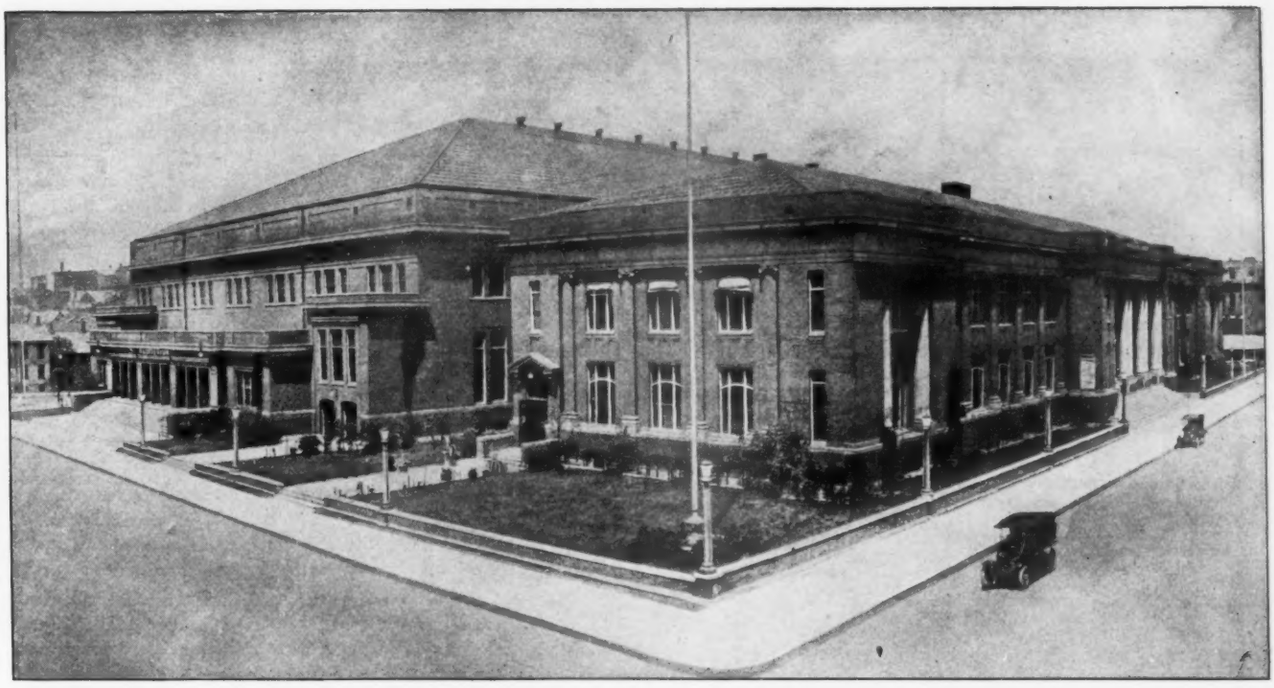
William G. Hammerstrom, chief engineer of the Lynchburg Foundry Co., Lynchburg, Va., has been promoted to the position of general superintendent, having charge of the company's three plants at Lynchburg and Radford, Va., and Anniston, Ala.

J. B. Henry, general superintendent of the Union Steel Casting Co., Pittsburgh, has been elected vice president, to succeed J. P. Allen, who became president recently. Mr. Henry will continue in charge of foundry operations. W. C. Eichenlaub, secretary, has been appointed sales manager.

C. E. McArthur, who recently resigned as superintendent of the J. I. Case Threshing Machine Co., Racine, Wis., to accept the position of works manager at the plant of the Barnes Foundry & Machine Co., has resigned this position, owing to the fact that the Barnes company has abandoned its plan to make automobile castings. Mr. McArthur has been appointed foundry superintendent of the Greenlee Foundry Co., Chicago.

C. Philip Coleman, president, Worthington Pump & Machinery Corp., 115 Broadway, New York, has announced the following appointments: James E. Sague, vice president in charge of engineering and manufacturing; Leon P. Feustman, vice president in charge of general commercial affairs, including contracts, prices, purchases, traffic, etc.; Frank H. Jones, vice president in charge of sales: William Goodman, assistant to James E. Sague, vice president; William Schwanhausser, chief engineer; Neil C. Lamont, manager, Laidlaw works, Elmwood place, Cincinnati; Edward T. Fishwick, general sales manager; and Charles E. Wilson, assistant to the general sales manager.

Harry Y. Carson, sanitary engineer for the Central Foundry Co., 90 West street, New York, has accepted a commission as chief sanitary engineer for the Red Cross relief expedition, which sails shortly for Palestine. The purpose of the expedition is to improve the deplorable sanitary conditions prevailing in Jerusalem and other parts of Palestine now occupied by the allied forces. For this work, Mr. Carson already has purchased $300,000 worth of engineering supplies. Included in the duties ahead of Mr. Carson is the installation of piping from the Pools of Solomon to Jerusalem, eight miles away.



The Milwaukee Auditorium Where the Activities of the Annual Meetings of the American Foundrymen's association and the American Institute of Metals will be Centered

Foundrymen Will Meet in Milwaukee

MILWAUKEE, one of the leading foundry centers of the United States; has been selected as the 1918 meeting place for the annual conventions of the American Foundrymen's association and the American Institute of Metals. Concurrent with these gatherings will be held the usual exhibition of foundry equipment and supplies, machine tools and accessories. On Monday, Oct. 7, the deliberations of the two foundrymen's technical societies will be opened with a joint session and at the same time the visitors will be given their first opportunity to inspect the displays. The convention and the exhibition will continue throughout the week.

The meetings of the American Foundrymen's association and the exhibition will be held in the Milwaukee auditorium, where ample display space will be afforded and a sufficient number of large meeting rooms are available for the joint sessions which will be scheduled for three days of the week. This commodious building will be the center of all the foundrymen's activities and here the headquarters will be established for both organizations.

The auditorium is one of the largest and most commodious structures of its kind in the world. Machinery hall, where the operating exhibits will be assembled, has a floor area of 54,000 square feet, and the arena, where the still exhibits will be located, has a floor area of 22,500 square feet. If necessary, the stage, 50 x 68 feet, also may be used for exhibition purposes. Two large meeting halls are located on the first and second floors, respectively, and are separated by wide corridors from the exhibition areas, thereby insuring freedom from noise. Milwaukee also has ample hotel facilities to provide accommodations for the 3000 to 3500 visitors who attend these affairs.

Milwaukee is one of the largest foundry centers of the United States, and provision will be made for plant visitation throughout convention week. Within the confines of the municipal limits of the city are located about 80 gray iron, steel, malleable iron and brass foundries, and including North and South Milwaukee and West Allis, the total is in excess of 90. Racine, Wis., only a short distance from Milwaukee, is the center of approximately 20 foundries. Milwaukee also is one of the leading steel casting districts of the world. It has approximately 20 steel foundries, a number of which recently have installed small open-hearth and electric furnaces. According to the 1914 statistics, the value of iron, steel and heavy machining of Milwaukee exceeded that of any other of its industries with a total of $34,300,585, and it is estimated that last year this totaled more than $50,000,000.

The committee of the American Foundrymen's association empowered to decide upon the time and place of the 1918 convention and exhibition consisted of the following: Benjamin B. Fuller, president, Westinghouse Electric & Mfg. Co., Cleveland; C. E. Hoyt, exhibition manager, Chicago; H. R. Atwater, Cleveland Osborn Mfg. Co., Cleveland; S. T. Johnston, S. Obermayer Co., Chicago; V. E. Minich, Sand Mixing Machine Co., New York, and A. O. Backert, secretary-treasurer, Cleveland.

Zinc Value Declined in 1917

While zinc production last year was about equal to that of 1916 in tonnage, the value suffered a loss of approximately $60,000,000. The production of spelter from domestic ore in 1917 is estimated by the United States geological survey at 574,994 short tons, valued at $102,350,000. The foreign production from foreign ore is estimated at 92,757 tons making the total output for the year 667,751 tons, valued at $118,860,000. This compares with the total of 667,456 tons, valued at $178,878,000 the previous year.

C. W. Hunt & Co. announce the removal of their New York City offices from 45 Broadway to the Astor Trust building, 501 Fifth avenue.

THE FOUNDRY

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Aliens in the Foundry Industry

PROBABLY a greater proportion of aliens are employed in the foundries of the country than in any other industry. It is essential that the proper precautions be taken to safeguard your plant against enemy depredations. A practical method by which this problem may be solved is to take a census of all employes, dividing them into four classes, namely native born, naturalized citizens, friendly aliens and alien enemies. Make an analysis or a map of your plant showing its vulnerable spots. Where will a fire do the greatest damage? Where is waste accumulated? What hydrant is most vital in extinguishing a fire? Where is the control of your lighting system? Where will an explosion cause the most damage? These and many other factors must be considered. Then find out what kind of workmen are in charge of these vulnerable points. If they are enemy aliens, transfer them at once. Some other point in the shop will not decrease their efficiency and it may increase your safety. Surveillance, guards and sentinels are the next most important considerations. When fences are built, windows barred and guards established, do you consult your factory plan to see that every vulnerable part is included? Safeguarding is a job of engineering, not a makeshift job that anyone can do without study.

Lighting is the next important essential. Every possible improvement should be made, vulnerable points snould be especially well lighted. Keep alien enemies and persons of doubtful loyalty in the light all of the time. Keep outsiders out. One way to keep outsiders out is to reduce your labor turnover. Every time a new man is employed who is not known, it increases the risk. Now that the registration of enemy aliens has been completed, ask every new employe if he has such a registration card. If your shop is handling war supplies of the first magnitude try to get every alien enemy out, not by throwing him out, but by exchanging with some industry that is not manufacturing war supplies, and thus aid in conserving the labor supply.

Take a personal interest in the alien. If it is necessary, set up an information bureau to help him understand drafts and regulations and registration. If he wants to learn English and become a citizen, help him to do so. See that he gets American information on bulletin boards, in pay envelopes and otherwise, to offset the anti-American material supplied him.

When this intelligent handling of alien enemy and those of doubtful loyalty is in operation, the plant is ready for another step—the systematic removal of every possible cause for unrest, dissatisfaction, disloyalty and disturbance. This will require a close contact with the workman, and another analysis of the plant. Is it wages, or hours, or foreman or the employing and dismissal method, housing or substitution of women? Whatever it is, it constitutes the medium through which enemy agents work and it is their chief stock in trade. In dealing with German spies a plant must be fool proof as well as bomb proof. The man who strikes may think it for bad treatment or bad housing. The spy plays on these conditions. The American government cannot protect the plant that will not protect itself, and the invisible war being carried on in American industries must be won by American manufacturers or the visible war in Europe will be lost.

Equipment for Iron, Steel and Brass Foundries

Improved Sand Cutting Machine—Increase in the Capacity of Electric Furnaces—Tapering of Core Prints—Power Operated Post Squeezer

AN improved sand cutting machine, built by the Sand Mixing Machine Co., New York, has been designed at its plant in Cleveland. This new model has been subjected to severe test in one of the largest automobile casting shops in the country for several months, cutting and tempering molding and facing sand, and so satisfactory have been the results that preparations now are being made to manufacture these machines on a production basis.

Designed on Automobile Standards

While the new model follows the construction of the present machine in principle, the design is based on the latest automobile and motor truck practice and where possible, the same engineering standards are adhered to. The frame is made of steel tubing of large diameter, joined at the corners by steel castings, which impart strength and flexibility with minimum weight. The front wheels are carried on ball bearings and are inclined 5 degrees from the vertical to bring the spindle directly over the point of contact with the floor to make steering easier. The spindles move up and down in a housing which is protected from dirt with a telescoping canvas sleeve. The rear wheels are wider than those on the former model and are mounted on roller bearings. The steel yoke which carries the rear wheel extends up and carries the upper section of the frame. The cutting cylinder hoisting mechanism is securely mounted on this frame.

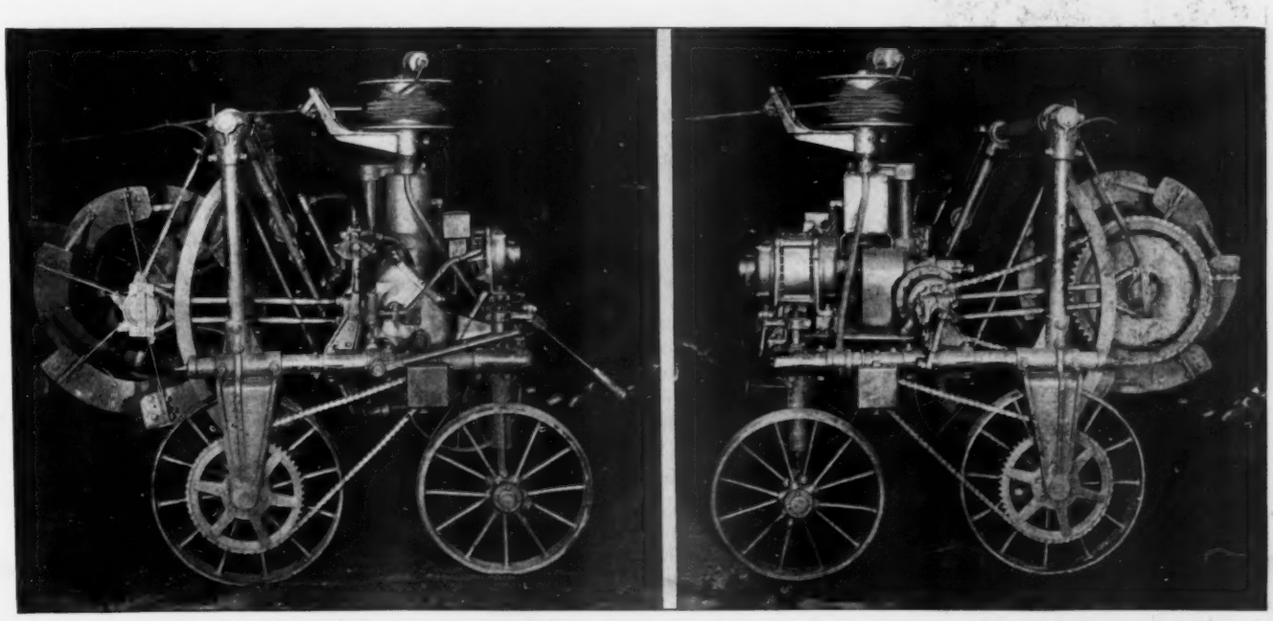
As in the present model, an electric motor furnishes the motive power through a worm reducing gear. A vertical take-up reel handles the electric cable with an even tension and winds it on the drum direct without passing over guiding sheaves. A sensitive adjustment is provided for the tension on the drum. To prevent breaking the cable, if the machine is run further than the cable length, a heavy circuit breaking plug is attached to it which separates the machine from the source of power when the cable is extended its full length. Current is carried from this reel to the switch and motor through conduit.

The transmission has two speeds forward and two speeds reverse, and runs in an oil-tight case. Lubrication is by means of splash and rotary pump. Two clutches, of the multiple disc type are used, one for forward and one for reverse travel. The clutches are engaged by internal ball-bearing wedges operated through a hollow shaft. All gears are alloy steel, hardened and heat-treated. A standard type of gear differential is used, which is mounted on high-duty roller bearings. All shafts are hardened and ground and run on roller bearings. The case is so constructed that access may be had quickly to any part for inspection or adjustment. The case is suspended on the chassis at three points.

The cutting cylinder unit has been so designed that it absorbs a large amount of the shock. This is accomplished by mounting the cutting blades on sigle leaf automobile springs which are attached radially on the cylinder tube. The cylinder is driven by heavy roller chain. The operating clutch also is of the multiple disc type mounted on roller and ball bearings. It is enclosed in an oil-tight case attached to the worm reducing gear and runs in a bath of oil. A brake is provided which stops the cylinder instantly when the clutch is disengaged.

Automatic Hoist Provided

A novel feature of the machine is the oil hoist which is provided to raise and lower the cutting cylinder. The hoist is mounted on the upper and rear frame members and raises the cylinder the required distance by compounding the cable. The hoist is operated by a special, rotary pump mounted on the transmission case and controlled by a small indicating handle convenient to the operator. The device is automatic and fool-proof because the cylinder cannot drop any lower than the pistons will allow nor go up any higher than the cylinder full of oil will hoist it. Care was exercised in designing the machine to provide for continuous operation under severe conditions. All parts are standardized and interchangeable. At present the sand cutter will be made only in 5, 6, and 7-foot widths except when otherwise ordered. Two views of the improved sand cutter are shown in the accompanying illustration.



TWO VIEWS OF THE IMPROVED SAND CUTTING MACHINE BUILT BY THE SAND MIXING MACHINE CO.

Increase in the Capacity of Electric Furnaces

During the past year, the 20-ton electric furnace was introduced in steel manufacture and indications point to another increase in capacity to a standard maximum of 30 tons. In view of this tendency toward larger units, the General Electric Co., Schenectady, N. Y., developed an improved system of automatic control to handle the necessary motive power. These improvements became necessary as the rate of steel production in these furnaces had been increased by the use of higher capacity transformers and higher voltages, which permitted forcing power into the furnace at considerably higher rates.

The control panel, Fig. 1, is made in three sections. The top section contains three shunt relays and three contactor groups, the total number of each corresponding to the number of electrodes used. The middle section has three contract-making ammeters, each provided with dash pots and with coils equipped with taps, which are used to vary the amount of power supplied to the furnace. Underneath these are three small dial switches, connected to the coil taps. On the lower section are four knife blade switches with fuses, one switch being used for the line and the other for the electrode motors. Each contactor group consists of three units, all mechanically interlocked, two contactors being normally open and one being normally closed. Facing the panel, the contactor at the left of any group

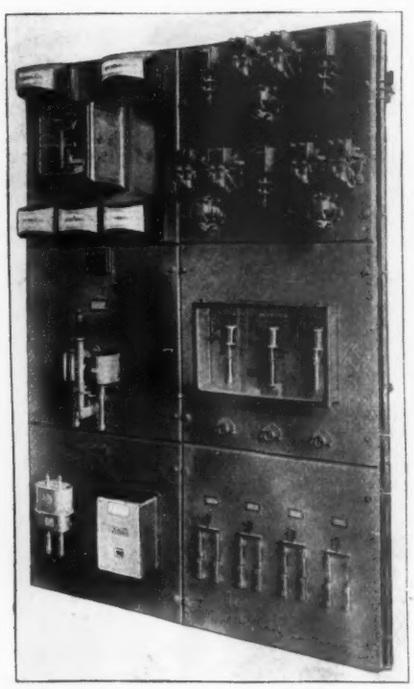


FIG. 1 — HAND AND AUTOMATIC-CONTROL SWITCHBOARD FOR ELECTRIC FURNACES

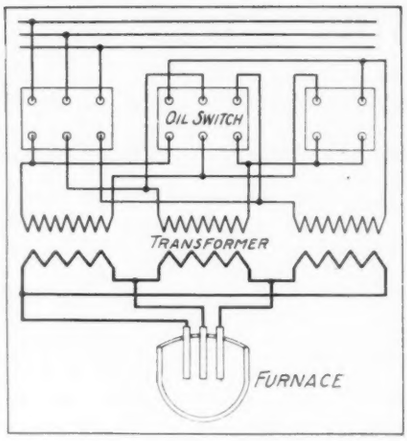


FIG. 2—CONNECTION DIAGRAM OF 3-PHASE FURNACE ARRANGED FOR VARIABLE VOLTAGE OPERATION BY CHANGING HIGH VOLTAGE CONNECTIONS

makes the necessary connection to raise the electrode, while the right-hand contactor causes the electrode to be lowered, and the bottom contactor short-circuits the motor armature through a resistance, in this way dynamically braking all the moving parts and stopping them almost instantly. A higher resistance is connected in circuit with the armature when lowering than when raising, this being done to keep the speed approximately constant.

Method of Control

The shunt-wound electrode motor is connected to the line until the desired regulation is obtained, when the motor is disconnected and stopped almost instantly by means of dynamic braking, this method insuring positive control of the electrode movement. This type of motor was designed for this particular service and ranges in size from 1 to 1½ horsepower for small equipment to 5 horsepower for 15 to 20-ton furnaces. While 100 volts remain standard for refining, voltages up to 173 have been used for melting. These voltages are obtained either by high voltage taps or high voltage Y-data. The use of high voltages during melting permits a decrease in the current for a given input, improves the power factor and insures higher emergency input when most needed.

A connection diagram of a 3-phase furnace arranged for variable voltage operation by means of changing the high voltage connections, is shown in Fig. 2. The high melting voltage is obtained by connecting high voltage units delta, and the low refining voltage by connecting them Y. Fig. 3 is a connection diagram of electrode furnace equipment in which a variable voltage is obtained by means of high voltage taps and external reactance is provided to be cut in during the melting period.

The Tapering of Core Prints

By F. J. Townsend

Should bottom core prints be tapered the same as top prints? This is a question which might appropriately be discussed by foundrymen generally. We are giving bottom prints only the slight draft used for patterns and if the change indicated should be made we would like to know the reasons therefore.

A claim of this effect is made in Chapter X of a book entitled "Wood Patternmaking", by Horace Traiton Purfield, as follows:

"A great many castings are lost because the lower print of vertical cores are made nearly parallel, or with the ordinary pattern draft. The probable cause of this is that the core does not go down to the bottom of the mold since the sand is cut down by the core not setting; so, when the cope is closed, being too long, it breaks the mold around the print of the core, allowing metal to flow into the vent and thereby causing the casting to blow. This may be overcome to a large extent by tapering the lower print as is usually done in the case of the upper one. If this is attended to there can be no trouble in setting the core. Indeed in the case of small cores, the molder can set them enough faster to pay for the extra work of pasting such cores together. As this is the main objection to this shape of print, namely, the necessity of making the cores in halves, it will be more than overbalanced by the advantage

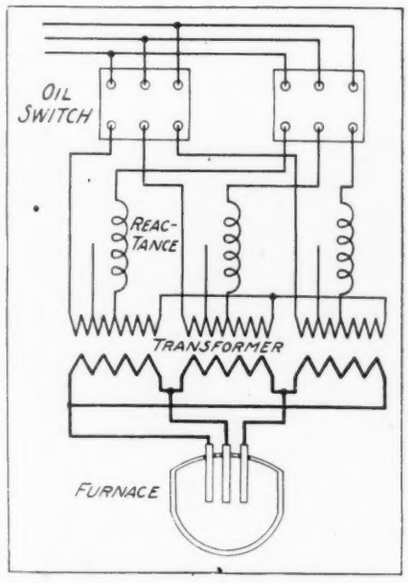


FIG. 3 — CONNECTION DIAGRAM OF ELECTRIC FURNACE EQUIPMENT. VARIABLE VOLTAGE IS OBTAINED BY HIGH VOLTAGE TAPS AND EXTERNAL REACTANCE IS CUT IN DURING THE MELTING PERIOD

of the greater facility and rapidity with which the cores can be set, to say nothing about the larger output of sound castings."

An Extended Layout Stick

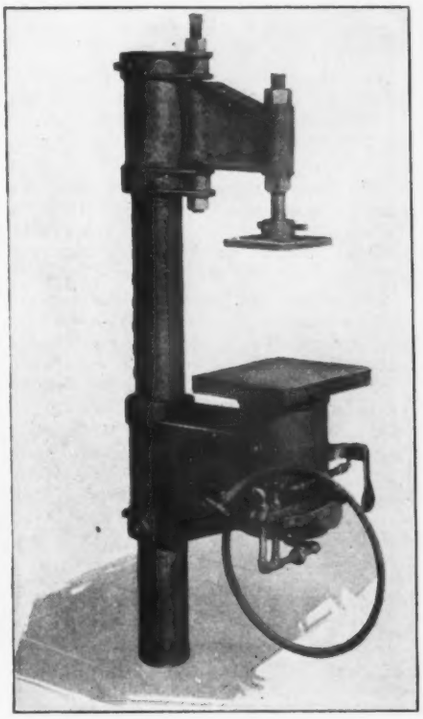
By S. L. Cook

Dimensions in excess of 1 foot must be laid-off with great care in patternmaking, where accuracy is paramount. When trammels are used and the longer dimensions are laid out on a stick, errors may occur through taking a wrong line for a base measurement. To obviate this chance of mistake, the following device is suggested:

Make a stick of pine or mahogany, about 1½ inches wide, 1 inch thick and 4 feet or more in length. On the edge of the stick lay off steps exactly the length of the scale and of sufficient depth to allow the scale to lie in each step with its surface flush with that of the preceding step. One foot from the first step set a brass screw, allowing the head to protrude sufficiently to be filed off flush with the surface of the stick. In this brass plug punch a small hole at exactly 1 foot distance from the end of the first step. This punch hole forms the center for the point of a trammel, and by laying a scale against the shoulder of any of the steps as desired, the other point of the trammel may be set with great accuracy to any desired dimension up to 4 feet or the extreme length of the stick. By laying-off steps on the different sides in accordance with different shrinkage scales, the utility of the stick may be increased.

A Power-Operated Post Squeezer

A power-operated post squeezer has been added to the line of molding machines manufactured by the B. & B. Mfg. Co., Indianapolis. The post to which the machine is attached consists of a heavy steel pipe, 6 inches in diameter, which is imbedded in concrete in the foundry floor. The machine is designed essentially to save space in the molding room and can be set up easily at convenient points. The cylinder operating the table of the squeezer is 7 inches in diameter and both this cylinder as well as the vibrator are operated by knee valves. The squeezer head and the table and cylinder section of the machine may be adjusted to any height. This is a particularly desirable feature since the lower part of the machine can be set in exactly the position for most convenient operation by the molder. When ramming the mold, the squeezer head is swung forward in the position shown in the accompanying illustration. After the mold has been made and the table lowered the squeezer head is swung aside out of the way. All operating parts are so constructed that wear may be taken up by set screws.



COMPRESSED AIR POST SQUEEZER BUILT BY THE B. & B. MFG. CO.

Steel Castings From a Small Open-Hearth Furnace

The La Plant-Choate-Williams Co., Cedar Rapids, Iowa, successor to the La Plant-Choate Mfg. Co., will install a 5-ton acid open-hearth furnace for the production of steel castings for its own use, and the surplus capacity will be devoted to castings for the jobbing trade. John S. Williams, formerly affiliated with the Commonwealth Steel Co., Granite City, Ill., Gould Coupler Co. and the Welland plant of the Canadian Steel Foundries, Ltd., will have charge of the steel casting department. The new company is incorporated with $150,000 capital, and will commence the erection of new buildings immediately. The officers of the company follow: President, E. W. La Plant; vice president, John S. Williams, and secretary and treasurer, R. E. Choate.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Clarke County Iron Works, Portland, Oreg., plans to build a gray iron foundry.

The Lamb Machine Co., Hoquiam, Wash., plans to build a foundry and machine shop.

The Standard Gas Engine Co., Dennison and King streets, Oakland, Cal., has had plans prepared for an addition to its foundry.

The Twin City Forge & Foundry Co., Stillwater, Minn., is building a plant, 130x400 feet, to cost $50,000.

The Hotz Foundry Co., Wolf avenue, Fremont, O., has started work on the construction of a foundry to be 60x60 feet.

Plans are being prepared by Frank Grad for a 30x95-foot foundry to be built by Max Mandel, Newark, N. J.

The Bowler Foundry Co., 1688 Columbus road, Cleveland, has awarded contracts for the construction of a foundry building, 75x200 feet, to cost $40,000. The company manufactures gray iron castings.

The American Car & Foundry Co., Depew, N. Y., plans to enlarge its plant by the erection of several additions and extensions.

Clifford & Owens, Marion, O., contemplate the erection of a 100x200-foot foundry and a 50x100-foot pattern shop, to be built on Cheney avenue, at a cost of $100,000.

Ford & Kendig, Philadelphia, plan to build a foundry and machine shop on a site purchased recently at Conshohocken, Pa. A. E. Wood is in charge of the new undertaking.

The Toledo Electric Steel Co., Toledo, O., will start work shortly on the erection of a 98x350-foot plant for the production of high speed tool steels.

The Iroquois Foundry Co., 108 Browns Race, Rochester, N. Y., is having plans prepared for the rebuilding of its plant, which was damaged severely by fire.

The Albert Clark Iron Foundry Co., Thirty-fifth street and Grays Ferry avenue, Philadelphia, will rebuild its core oven department, severely damaged by a recent fire.

The Central Aluminum & Brass Mfg. Co., Detroit, has awarded a contract for the erection of a new plant to cost $25,000. The structure will be 100x180 feet.

The Orben Stove Co., Belleville, Ill., recently incorporated with a capital of $50,000, contemplates building a foundry. J. A. Langfelder is in charge.

The Lutz Co. Inc. of New Jersey, Camden, N. J., has taken over the plant of the Joseph Pedrick Foundry Co., Twenty-fourth street and Hayes avenue, which it will enlarge and equip for the production of cast-

ings to be used in the manufacture of pneumatic tools. R. A. Rutherford is in charge of the work of expansion.

The Peoria Foundry Co., 1306 South Washington street, Peoria, Ill., recently incorporated, will build a foundry. J. F. Hadank is in charge.

The Universal Foundry Co., Oshkosh, Wis., has increased its capital from $10,000 to $25,000 to provide for contemplated extensions. Robert Ziebell is president.

The Lansdale Foundry Co., Lansdale, Pa., manufacturer of gray iron castings, is erecting another pattern storage building, 40x60 feet and the pattern shop is being enlarged by an addition, 40x60 feet.

The Enterprise Brass Foundry Co., Muskegon, Mich., has nearly completed the erection of an addition to its plant on Peck street.

The Buchanan Foundry Co., Philadelphia, has purchased the plant of the Scranton Axle & Spring Co., which it will equip for the production of gray iron castings.

The plant of the Monarch Steel Castings Co., Solvay avenue and the Wabash railway, Detroit, which has been severely damaged by fire, will be rebuilt shortly.

W. A. Holcom, Poplar Bluff, Mo., plans to build a large foundry and machine shop at Newport, Ark. Mr. Holcom owns a plant of this kind at Poplar Bluff.

The Pittsburgh Steel Foundry Co., House building, Pittsburgh, plans to build a new plant at Glassport, Pa., for the production of iron and steel castings.

The Eagle Brass Foundry Co., 505 Railroad avenue, Seattle, has increased its capital stock to $50,000 to provide for building an addition to its plant.

The Monarch Brass Co., 1621 East Forty-fifth street, Cleveland, has awarded contracts for the construction of a foundry, 90x100 feet.

The Standard Steel Castings Co., Clearing, Ill., has started work on a 100x200-foot plant. The cost of the finished structure is estimated at $100,000.

The General Aluminum & Brass Mfg. Co., Boulevard and St. Aubin avenue, Detroit, has awarded the contract for a new plant to cost $25,000.

The Hudson Foundry Co., New York, has been incorporated with a capital of $20,000. The incorporators are J. Mittelman, J. C. Garret, 27 William street, and others.

The L. N. N. Foundry Co., Cleveland, has been granted a charter of incorporation with a capital of $20,000. H. H. Neuman and C. E. Lyall are interested.

The N. B. Gaston & Sons Co., Beloit, Wis., manufacturer of scales, is building a number of additions to its plant, including extensions to its machine shop and foundry. New equipment also is being installed.

The Marion Machine, Foundry & Supply Co., Marion, Ind., has taken over the plant of the Planet Steam Specialty Co., which it will equip for the manufacture of soot blowers and boilers.

The National Foundry Mfg. & Supply Co., Williamsport, Pa., plans to rebuild its plant at Hepburn and Canal streets, which was damaged by fire recently. A new structure, to cost $10,000, will be erected.

The plant formerly operated as a machine shop by the J. S. Rowell Mfg. Co., Beaver Dam, Wis., has been sold to Edward Herzberg and others, who will equip the plant for the production of gray iron castings.

The Otto Biefeld Co., Watertown, Wis., will build an addition to its plant, to include a foundry and pattern shop. The building will be of brick and steel construction, 66x214 feet.

The Perryville Stove Co., Perryville, Ind., will build a foundry, machine shop and cleaning room. Plans have been prepared by E. U. Garrett, architect, 9 West Harrison street, Danville, Ill.

The Atlas Brass Foundry Co., 980 South Park street, Columbus, O., will build a 3-story addition to its plant. The company manufactures brass, bronze and aluminum castings. John Whittman is president.

The Morrison Foundry Co., 111 Gotthart street, Newark, N. J., manufacturer of gray iron castings, has increased its capital from $100,000 to $200,000 to provide for building an addition to its plant.

The Detroit Engineering & Foundry Co., Detroit, contemplates building a plant at Lorain, O., where it has an option on a tract of 20 acres on the New York Central railroad.

The Alloys Mfg. Corp. has been organized with a New York charter to manufacture die castings. The company is capitalized at $250,000 and its incorporators are C. W. Lucas, H. C. Wing and M. M. Grunthal, 27 Cedar street, New York.

The Davis-Price Foundry & Machine Co., New Cumberland, W. Va., has taken over the plant of the Hancock Foundry & Machine Co., which it will remodel and expand. G. L. Bambrick is president of the new operating company.

The Green Bay Foundry & Machine Co., Green Bay, Wis., manufacturer of paper and pulp mill machinery, has been sold to a group of Chicago financiers, with whom R. A. North, Green Bay, Wis., is associated. The new owners plan to build a number of extensions to the plant and to install considerable new equipment.

The Gas Traction Foundry Co., 2907 South East Fourth street, Minneapolis, will build a foundry addition to its plant, to be 100x300 feet, at a cost of $70,000. Plans have been prepared by W. L. Alban, Endicott building, St. Paul.

A charter of incorporation has been granted to the Saugerties Foundry & Machine Co., New York, capitalized at $20,000. The incorporators include F. C. Smith, E. North and G. W. Levitt, 1 West Seventy-second street.

The Morris Machine Works, East Genesee street, Baldwinsville, N. Y., will build a foundry, 100x210 feet, at a cost of about $25,000. The company is in the market for foundry equipment. Smith & Caffrey, Syracuse, N. Y., are the architects.

The A. L. Swett Iron Works, Glenwood avenue, Medina, N. Y., will increase its capital stock from $200,000 to $500,000, to provide for building additions to its plant and installing new equipment. The company operates a gray iron foundry.

NEW TRADE PUBLICATIONS

IRON CEMENT. — A 16-page instruction booklet, detailing the uses and application of iron cement, has been issued by the Smooth-On Mfg. Co., Jersey City, N. J. The use of this cement in foundry operations requires no explanation. It can be employed to advantage for repairing castings when their strength is not affected by the blemishes.

GAS ENGINES.—The line of gas engines built by the Chicago Pneumatic Tool Co., Chicago, is illustrated and described in a 20-page bulletin recently issued. This engine is of the horizontal, straight line type, with crosshead and two-stroke cycle operation. It is built as a single cylinder machine in sizes from 16 to 110-horsepower and as a duplex machine from 70 to 220-horsepower.

ADJUSTABLE SPEED MOTORS.—A 4-page bulletin issued by the General Electric Co., Schenectady, N. Y., is devoted to adjustable speed motors of various types, including those equipped with open end shield, enclosed ventilated, totally enclosed, compensated shunt, etc. Detail views of the motor parts, as well as a table of dimensions, are included.

DRUM-TYPE SWITCHES. — A 6-page folder, issued by the General Electric Co., Schenectady, N. Y., is devoted to drum-type switches for throwing small alternating or direct current motors across the line without the use of starting resistance. The size of the motor that can be so started depends upon its characteristics and the limitations set by the power company. The folder describes various types of drum-type switches manufactured by the General Electric Co. for this service.

BRASS FOUNDRY SUPPLIES. — "Suggestions for Brass Foundrymen" is the title of a 96-page catalog issued by Frederic B. Stevens, Detroit, and as its name implies, practically all equipment and supplies used in brass foundry operations are listed. Natural draft furnaces first are described followed by such necessary furnace accessories as blowers, crucible shanks, tongs, crucibles, etc. All of the necessary equipment for the brass foundry is illustrated and described, including sand sifters, riddles, core-making machines, core ovens, core wire straighteners, snap flasks, cast iron flasks, clamps, air and electric vibrators, tumbling barrels, sprue cutters, magnetic separators, etc. Several pages of foundry notes and formulas also are included.

SANITARY DRINKING FOUNTAINS.—A 20-page booklet, issued by the D. A. Ebinger Sanitary Mfg. Co., Columbus, O., illustrates and describes the extensive line of drinking fountains manufactured by this company. Some types of these fountains are particularly adapted to installation in industrial plants and a fountain of the pedestal type with porcelain bowl, bronze pedestal, bubbler, concealed galvanized supply and waste pipe and regulated valve with loose key is shown for this purpose. A cooler fountain also is illustrated which is a combination of a water cooler and fountain, the cooler being mounted on a cast iron bronze pedestal and is provided with a vitreous enameled fountain receptor and a supply pipe to the fountain with self-closing and stop valves. The ice chamber is provided with drain, overflow and coil guard. Numerous other types of drinking fountains also are shown. In addition, a comprehensive catalog of 108 pages devoted to ventilated toilet fixtures for factories, schools, public institutions, etc., also has been issued. A valuable feature of this work is the large number of layouts of lavatories of various types.